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APPLIED MECHANICS REVIEWS

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ELECTROANALOGIC METHODS

IV. A useful auxiliary, dimensional analysis—basic theory

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PARTS I, II, III, and IV, of this article [see AMR, January and February, 1956; February and August, 1957] respectively comprise an account of electroanalogic solution by continuous-type conductive (tank, plate, sheet or liquid surface) procedures of problems of electric and magnetic nature [1-111],[1] of continuum-mechanics (elastic, thermic, hydrodynamic, and aerodynamic) nature [112-314], and of solution of like and other (electric, water, gas and steam distribution, electron-optics systems, and nuclear reactor design) problems [315-480] by the discrete-type conductive procedures afforded by d-c resistance networks. This part IV encompasses account of the basic theory of a most useful auxiliary with, and powerful supplement to, these conductive procedures: namely, the method of dimensional analysis *(481-499)*.[2]

31. ORIGINS

The genesis of the modern theory of dimensional analysis is rooted in the concept of geometric similitude *(500)*: as manifest in use of the pertinent principles by, among the first, Galileo *(501)* (for determining the elastic properties of simple structural members as a function of their geometric dimensions), Newton *(502)* (in study of the laws of motion), and Marriotte *(503, 504)* (in work on shock and on fluid flow). Roughly a century and a half later, Fourier *(505)* advanced two prime tenets underlying the general development to date: The concept of "dimensional formula" and the principle of "dimensional homogeneity." The first provides simple algebraic expression (the dimensional formula) of the unit of a physical quantity in terms of letter (usually) symbols characterizing the units of certain chosen basic physical quantities; the second affirms (in virtue of later refinement) that when an equation characterizing a physical phenomenon is of "simplest form" the dimensional formulas of the terms comprising it are necessarily of the same dimensions, thus uniformly couched in the mentioned symbols. This early work on similitude and homogeneity was critically reviewed and utilized by Bertrand *(506, 507)* at midcentury in the course of certain work in mechanics and, later, electricity *(508, 509)*.

32. CONVERSION OF UNITS

Perhaps the first considerable connected body of writing on dimensional analysis initiated in modern times is that which has to do with (i) change of the numerical value pertinent to a physical quantity because of change in the system of units in which it is measured, (ii) consideration of the necessary, the minimum, or a permissible number of "fundamental" physical quantities, and (iii) determination of the nature and dimensions of physical quantities in general, and of electric and magnetic quantities in particular. The character and course of procedures pertinent to (i) are both well-defined and little changed since, for example, publication of the interesting paper by James Thomson *(510-516)*, brother of the better-known William Thomson (Lord Kelvin), in 1878.

33. DIMENSIONS AND UNITS

Considerations of the type of (ii) are less defined *in toto*, more speculative and philosophic in character, and of such essential physical significance as to have engendered a very considerable body of closely detailed reasoning and analysis (and vigorously held opinion). Thus, an inclusive (and difficult!) reading of the literature evidences a rather interesting cycle of expansion, contraction, and re-expansion in the asserted permissible minimum number of fundamental units over the course of development and integration of classical and modern physics and technology: from three, to four, to five; therefrom gradually down to an absolutely-needed one; and therefrom upwards through an understanding that though only one is absolutely necessary, a considerable convenience can stem from using three, four, or five primary units as rendered feasible by the problem in hand.

Determinations of the type of (iii) have proved even more difficult to elucidate and resolve—whence a yet greater body of literature has resulted in an effort to do so. A critical reading of the pertinent text over the last eight decades (in large measure this body of work was initiated by publication of Maxwell's book in 1873, though the pertinent context thereof is foreshadowed in his great paper of a decade earlier) evidences no common concensus of agreement as yet.

In such fact, and in that the determinations of (iii) are inextricably linked with the considerations of (ii), one deeply interested in dimensional analysis may wish to attempt self-elucidation of this interesting phase of the subject. If so, he could, perhaps, best proceed by a chronologically pursued study of the *more significant* writings noted by the author in his reading *(517-601)* (special attention may be directed to the difficulties associated with electric and magnetic units *(602-632)*. However, for one interested in dimensional analysis as an

[1] Numbers in brackets [ ] indicate references at the ends of parts I, II, and III.

[2] Numbers in italic parenthesis *( )* indicate references at the end of this article.

auxiliary to electroanalogical methods, a sufficient purview (and insight to the general complexity of the situation) can be gained from a conjoined reading of the pertinent chapters in the books by Bridgman *(482)* (chaps. II, V), Birkhoff *(491)* (III), Focken *(499)* (III) and, especially, O'Rahilly *(599)* (XV).

34. THE PRINCIPLE OF SIMILITUDE

Mulling considerations encompassed in some of the foregoing references led Tolman *(632-634)* to advance his so-termed principle of similitude, enfolded in the remark: "The fundamental entities of which the physical universe is constructed are such that from them a miniature universe could be constructed exactly similar in nature to the present universe." This principle, though vigorously maintained by its author, was received skeptically, subjected to searching examination *(635-645)*, and is now considered as both untenable in nature and false in fact *(491,599)*.

35. THE PI-THEOREM

The essential usefulness of dimensional analysis as an auxiliary in electroanalogic procedures is encompassed in the so-called Buckingham pi-theorem, and in extensions to it and complements of it. Statement of this theorem in English in a well-known journal culminated, in fact, a gradual perception, tenuous use, crystallization into formula, and limited exploitation of specific relationship between the number of physical quantities characterizing a physical phenomenon and the number of independent dimensionless terms that could be formed within the restrictions of a chosen set of primary units. Thus, prior to Buckingham's publication in 1914, the germs are to be perceived in work stretching over two centuries *(500-509,646-648)*; Rayleigh *(649-652)* and Jeans *(653-654)* made extensive, if ambiguous, use of the essential principle; Vaschy *(655-663)* formulated it specifically at least by 1890; shortly thereafter others *(664)* cited him, but his work remained only partially known until Esnault-Pelterie *(488-490,665-667)* in recent years stressed his contributions; in which circumstance Riabouchinsky *(668-676)*, later (1911) reformulated it *(669-670)* near the beginning of a long career of study in aerodynamics, initiated in 1904 at his privately founded Kutchino Institute for Aeronautics (this lack of knowledge of Vaschy's work is specifically remarked by him *(673)*. A more rigorous proof was shortly advanced by Federmann *(674)*.

Interestingly, it was notice of a remark *(675)* of Riabouchinsky's *(669)* work on dimensional analysis that spurred Buckingham *(676,677)* to his formulation of the pi-theorem (so-called after the usual use of the pi symbol to designate a simple product, in the course of derivation)—as he later stated *(678)*.

This initial publication, and several papers *(678-682)* shortly thereafter, in well-circulated scientific and engineering journals gained a rapid dissemination of knowledge of the pi-theorem. Over the next several decades, a number of papers appeared *(697-704)*, some advancing new, unique, or more rigorously couched proofs of the pi-theorem and sharply pointed considerations in general *(683-695)*, others rather more tutorial or applied in nature.

Unique complements of the pi-theorem have been advanced by Hersey *(705,706)* (a relationship expressing the derivative of a dimensionless quantity occurring in the expression yielded by the pi-theorem) and by Esnault-Pelterie *(707,708)* (a limit law providing certain useful asymptotic information).

36. INSPECTIONAL ANALYSIS

A major tenet of dimensional analysis comprises testing for invariance under a certain transformation the ordinary or partial differential equations (and associated equations) characterizing a physical phenomenon *(709-712)*. The necessity of such, explicitly or implicitly, and the values stemming from such "inspectional analysis," especially in fluid mechanics phenomena, has been stressed by Birkhoff *(491)*.

37. CONCLUSION

The fruit of the large body of theory discussed in this paper is a very considerable body of work on special problems in many domains of science and technology. Of especial interest is that on modelling, since it is in this connection that dimensional analysis is most useful as an auxiliary to electroanalogic procedures. Coverage of this body of work comprises Part V of this series.

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"Books Received for Review" appear after the reviews

Theoretical and Experimental Methods

(See also Revs 2393, 2402, 2415, 2420, 2430, 2465, 2481, 2483, 2484, 2496, 2505, 2506, 2648, 2655, 2678, 2679)

Book—2373. Temple, G., and Bickley, W. G., Rayleigh's principle and its applications to engineering, New York, Dover Publications, Inc., 1956, 152 pp. $1.50.

Book—2374. Lalescu, T., Introduction to the theory of integral equations [Introducere la Teoria Ecuatiilor Integrale], Bucaresti, Editura Academei Republicii Populare Romane, 1956, 131 pp. Lei 5.90.

2375. Mauersberger, P., The Neumann method for the approximation of a through observation obtained function and its connections with the mechanical quadrature of Gauss-Jacobi (in German), *ZAMM* **36**, 9/10, 372–376, Sept./Oct. 1956.

Author gives a generalization of Neumann's method for approximating, by means of orthogonal polynominals, a function of n variables given for discrete values of the independent variables. He introduces some new ideas, as "orthogonal-relation" for finite sums and the use of the Gauss-Jacobi quadrature, so that the proofs and calculations can be simplified and no compensating computation is needed. J. Polasek, Czechoslovakia

2376. Tables of Whittaker functions, wave functions in Coulomb Field, *Numerical Computation Bureau, Tokyo Rep.* 9, 66 pp. 1956.

Report no. 8 of this series presented tables relating to Whittaker's function $W_{k,l+1/2}(x)$ and its derivative for $l = 0$ and vari-

ous values of real k and x [see AMR 8, Rev. 1896]. The present item is similar with k and $-x$ pure imaginary. Omitting the imaginary unit, tables are given to 6d for

x: 0(0.05)2.0(0.1)5; $y = 1/x$: 0(0.005)0.2 and k: 0(0.02)1.0

Some auxiliary functions are tabulated to facilitate interpolation near the origin. Second central differences are provided in both directions. An introduction gives some formulas, but these are not complete, and the general criticisms made in above review pertain to the one at hand. Tables are valuable and should prove useful to many workers. Y. L. Luke, USA

2377. Thompson, P. D., Optimum smoothing of two-dimensional fields, *Tellus* **8,** 3, 384-393, Aug. 1956.

Author deals exclusively with smoothing of nonsystematic errors of reported measurements or other small-scale random fluctuations. Wiener's methods for stationary time series are extended to two-dimensional fields whose autocorrelation functions are invariant with rotation. Optimum (RMS difference true and smoothed fields least) weighting function is found to be a linear combination of Bessel functions for fields whose autocorrelation functions have shape of Gaussion error function.

Comparison of optimum averaging with analyst's subjective smoothing indicated the former to be superior. Minimum RMS error of linearly smoothed fields is expressed in terms of signal-to-raise ratio, standard deviation of true field and scale ratio.

Reviewer thinks that this paper will be of great interest to engineers who are concerned with problems involving smoothing of two-dimensional fields of observations.

F. H. Bushby, England

2378. Table of square roots of complex numbers, *Numerical Computation Bureau, Tokyo Rep.* 10, 21 pp. 1956.

Book—2379. Locke, W. N., and Booth, A. D., edited by, Machine translation of languages, Cambridge, Mass., The Technology Press of Massachusetts Institute of Technology; New York, John Wiley & Sons, Inc.; London, Chapman & Hall Ltd., 1955, xii + 243 pp. $6.00

This is the first book on the problem of machine or mechanical translation. It is a collection of fourteen essays and a bibliography of 40 other papers.

The essays are devoted to various topics, such as the problem of the "word"; design of an automatic dictionary; input and storage devices; idioms and syntax; model English; operational analysis of Russian. The book is not easy reading, and many varied views are presented regarding the problem.

Historically, the first step was made by Dr. Warren Weaver in 1949 when he circulated a private memorandum "Translation," which is reprinted in this volume. Several years later Massachusetts Institute of Technology was host to the first symposium on the mechanical translation of languages. Since that time a great deal of work has been done in this country and abroad in the engineering and linguistic problems which have to be solved before machine translation becomes more than a laboratory project.

Several attempts have been made to show that mechanical translation is possible, but these have been small and have served only to point out that much work needs to be done. Some of the problems are in the area of storage devices, linguistic analyses of languages suitable for machine application, and economic feasibility of machine translation.

The book is recommended to anyone who is interested in the problem of machine translation. W. A. Kalenich, USA

2380. Bondar, M. G., Electrical simulation of the dynamic stability of systems of bars (in Russian), *Dopovidi Akad. Nauk Ukrain. RSR* no. 5, 356-360, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1654.

It is suggested to use an electric matrix simulator with quadripoles (amplifiers) for solving the problem of the stability of a bar system described by a system of linear differential equations of the second order with variable coefficients. A comparison is made between the equations of the initial system and the simulator on the assumption of ideality of the amplifiers (amplification coefficient w = const) and the passive elements (L, C, R) of the matrix system. The comparison is made without analysis of the possibilities of realization of the electrical matrix system with inductive and capacitive coupling, analysis of the conditions of parasitic self-excitation, or the accuracy of simulation. The author also introduces an error of principle (cf. p. 358, line 7 et seq.), correlating in the simulator the behavior of the active, directional quadripole amplifier with that of the passive quadripole, the transformer. I. M. Tetel'baum, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Book—2381. Wallis, W. A., and Roberts, H. V., Statistics: a new approach, Glencoe, Ill., The Free Press, 1956, xxxvi + 646 pp. $6.

Up-to-date introductory survey of statistical methods is based on critical examination of the nature of statistical reasoning. Treatment of problems of inference from counts and measurements, and chapter on shortcuts (dealing with nonparametric tests of selected types of hypotheses) are relevant for most engineers.

Presentation is interesting, logical, nonmathematical. Over 200 lively examples are deliberately selected from diverse fields to emphasize the unity of statistical methods. A large proportion of these illustrations are of general interest and some deal specifically with engineering problems.

Reviewer believes this an exceptionally good general statistics volume, either for classroom or individual use. Practicing researchers' acquaintance with Wallis and Roberts will encourage them to pursue the sizeable benefits which good statistical design can yield in the amount of information obtained for a given investment in experimental work, or, conversely, in economy for achieving a required determination. If so, engineering researchers may be led to more explicit "models" of the data-generating systems which they observe, and more rational data reduction and analysis. Statistical consultants may receive more calls for advice—and earlier in the planning of research programs. Also, more engineers are likely to wish to explore for themselves more sophisticated statistical methods, beyond the scope of the present work.

B. Ladd, USA

2382. Burke, P. J., The output of a queuing system, *J. Operat. Res. Soc. Amer.* **4,** 6, 699-704, Dec. 1956.

Paper helps clarify a situation in which intuition has heretofore been the master. The proof that the output of a single and multistage exponential service queue system fed by Poisson arrivals is itself Poisson simplifies the treatment of tandem queues. The proof is based on the demonstration of two principles: (a) that the distribution of interdeparture intervals is the same as that of arrival intervals; (b) that the interdeparture interval is independent of the state of the system at the end of the interval.

At the conclusion of the paper, author cites an example to demonstrate the simplifications which result from applying the results of the proof. E. Koenigsberg, USA

Book—2383. Oberdorfer, G., Measuring systems of physics and engineering [Die Massysteme in Physik und Technik], Wien, Springer-Verlag, 1956, vi + 140 pp. $3.80.

Book treats subject matter similar to that of a former work of the author: "Das natürliche Mass-System" [Wien, Springer Verlag, 1949]. It aims at setting up a system of measures unobjectionable

for both scientific and technical applications. The importance of this topic is evidenced by the number of papers written on the question, which has not yet been satisfactorily solved.

The introduction deals with laws describing natural phenomena and with quantitative equations expressing relationships between the different quantities observed. Every equation of this kind establishes a ratio between the dimensions implicated, as well as the measuring numbers figuring therein. Where adequate units of measure are chosen, only measuring numbers figure in the equation expressing the connections of measuring numbers. Then quantitative equations immediately become equations of measuring numbers too. Therefore the use of such coherent units is advisable.

Book treats intensively the different requirements that may be set up in relation to the systems of measures to be chosen. It demonstrates, which is its principal merit, that the number of basic quantities required for setting up a system of measures acceptable from any point of view cannot be selected at will. This number, the degree of the system of measures, is unequivocably determined by our knowledge of natural phenomena; as our knowledge progresses, this number may change. At the present state of our knowledge a system of three basic quantities is used in mechanics and a system of four in electricity. In thermodynamics it is advisable to replace the system of four basic quantities presently in use by a system of three.

Tables containing conspicuously arranged data and units of the most important systems of measures complete the book.

With its lucid reasoning the book is a useful aid in combating the confusion reigning all over the world in the field of systems of measures and is thus a lasting asset to technical literature.

P. Csonka, Hungary

2384. Ludovici, B. F., New system of physical units and standards, *Amer. J. Phys.* **24,** 5, 400-407, May 1956.

The present system of physical units and standards is critically examined from the viewpoint of a possible destruction of the present primary standards through a natural catastrophe. A new system is proposed. From author's summary

2385. Wierzbicki, W., The contribution of Feliks Jasiński to world science (in Polish), *Arch. Mech. stos.* **8,** 3, 293-317, 1956.

Paper presents a description of the scientific activity of F. Jasiński (1856-1899) and stresses his original contribution to world knowledge. The most important achievements of Jasiński are: (1) full rehabilitation of Euler's elastic buckling theory, based on the observation that the integration of the accurate differential equation of a deformed bar gives, in the limit, the same result as the integration of an approximate equation; (2) calculation of the critical force for eight new cases of end support; (3) analysis of stability of compressed girders of open bridges, now called "F. Jasiński's problem"; (4) introduction of the reduction coefficient of cross section in the calculation of compressed bars; (5) investigation of buckling of a bar acted on by an eccentrical compressive force and having an initial curvature; (6) introduction of a formula for bending of an eccentrically compressed bar; and (7) introduction of the length coefficient for various ways of clamping the ends.

W. Urbanowski, Poland

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2407, 2456, 2625)

2386. Kostitsyn, V. T., The dynamics of the mechanism of loop-sinking (in Russian), *Nauch. tr. Mosk. tekhn. in-ta legkoi prom-sti. Sb.* **5,** 233-244, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2682.

The question is examined of the loop-sinking of a stocking machine. The values are determined of the velocities and accelerations of the thread and of the needle preparing the thread for the formation of a loop; the values of the loads obtained as a result of the interaction of needle, thread, and platen are determined. The results of the dynamic stresses of the thread and of the dynamic pressures on the needle and platen are illustrated by graphs and hodographs.

Courtesy Referativnyi Zhurnal V. A. Zinov'ev, USSR
Translation, courtesy Ministry of Supply, England

2387. Katsnel'son, S. B., Some problems of the kinematics of a horizontal drawing press with two crankshafts (in Russian), *Trudi Mosk. vech. mashinostr. in-ta* no. 2, 263-271, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2676.

An equation is derived for the center trajectory of the central hinge of an articulated link during rotation of cranks with angular velocities which are identical in size and direction. The form of the trajectory is given for different particular values of the angle between the cranks.

Courtesy Referativnyi Zhurnal F. M. Kurovskii, USSR
Translation, courtesy Ministry of Supply, England

2388. Alekhnovich, N. V., Kinematic and kinetostatic investigation of plane mechanisms with two degrees of mobility by the graphical method (in Russian), *Sb. nauch. tr. Belorus. politekhn. in-ta* no. 44, (6) 460-475, 1954; *Ref. Zh. Mekh.* 1956, *Rev. No.* 2679.

The known elementary structures of the planes of velocities, accelerations, and forces for mechanisms having two guiding links each.

Courtesy Referativnyi Zhurnal V. A. Zinov'ev, USSR
Translation, courtesy Ministry of Supply, England

2389. Toropin, S. I., The differential physical pendulum with a single prism-pad system (in Russian), *Trudi Vses. n.-i. in-ta metrologii* no. 23, 5-17, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1291.

In the suggested construction for a pendulum, two moving weights are provided, one of which, of mass m, can occupy three different positions with centers distant Z_1, Z_2, Z_3, respectively, from the axis of rotation. The displacement $Z_2 - Z_3$ must be accurately measurable. The other weight can occupy two different positions above the axis of rotation, which are not rigorously fixed. By observation, the period T and distance H of the center of gravity from the axis of rotation are determined, from which the acceleration of gravity g can be determined. An investigation of the accuracy of determination of g shows that, with moderately rigorous assumptions in regard to the accuracy of the necessary measurements, the error of g will not exceed ± 3 mgal. Author's deductions are true only if the weight is not considered as a material point.

Courtesy of Referativnyi Zhurnal A. A. Mikhailov, USSR
Translation, courtesy Ministry of Supply, England

2390. Toropin, S. I., The influence of the prism and the "pad" in the absolute determination of the acceleration of gravity by means of a pendulum (in Russian), *Trudi Vses. n.-i. in-ta metrologii* no. 23, 18-25, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1292.

The variations in the period of oscillation of a pendulum are investigated in relation to the radius of curvature of the prism (i.e., knife-edge); the coefficient of elasticity of the prism (knife-edge) is supported.

Experimental investigations with three, four-pendulum arrangements gave a mean change of period of 57×10^{-7} sec when the pendulums were changed from one pad to another. Tests on the oscillations of the yoke with the same prism on the pad also gave perceptibly different periods. The correction for change in period of oscillation owing to the influence of the elasticity of the prism and pad can be expressed by two terms, one of which is proportional to the amplitude, and the other to the square thereof.

Courtesy of Referativnyi Zhurnal A. A. Mikhailov, USSR
Translation, courtesy Ministry of Supply, England

2391. Tavkhelidze, D. S., On the question of the complex analysis of mechanisms (On a point of order) (in Russian), *Trudi Gruz. politekhn. in-ta* no. 31, 17–24, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1330.

The effect is investigated of external forces acting on linkages, and the moments of the reactive forces arising in cinematic couples, on the determination of the motion of two-dimensional, quintuple hinge linkages with one driving link.

The analytical determination in general form of the positions of the mechanism in accordance with predetermined forces applied to the links is given, as well as the graphical determination (using diagrams of forces), of the law of change of the force to be applied to the joint formed by the connecting rods in order to obtain a predetermined change in position of the mechanism, without considering the moments of the frictional forces in the hinges.

The problem of determining the position of the mechanism with consideration of the moments of the frictional forces in the hinge joints is solved by a graphical method of successive approximation.

The conditions for the stability of the position of the mechanism in a concrete position of the driving element is stated.

Courtesy of Referativnyi Zhurnal P. A. Lebedev, USSR
Translation, courtesy Ministry of Supply, England

2392. Tamamshev, A. A., The problem of the positions of a quintuple linkage with varying dimensions of the links (in Russian), *Trudi Gruz. politekh. in-ta.* no. 34, 83–96, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1332.

A method is described for designing a two-dimensional, quintuply-hinged linkage in which the driving link performs a complete revolution while the driven link is arrested in the end positions. Links performing a complex, plane-parallel motion form a rigid system during motion of the driven element owing to self-braking in the kinematic couple connecting these links. In such case the mechanism acts as a quadruply-hinged system until the driven link reaches an end position. Thereafter, the driven link remains stationary while the connecting rods displace relatively until self-braking (self-locking) is repeated.

In any instant of time the mechanism in question constitutes a quadruply-hinged linkage, hence the method suggested is found on the known methods of determining the arrangement of a quadruply-hinged linkage according to predetermined positions of its links.

The method is further extended to the case of a two-dimensional, quintuply-linked mechanism in which the driven link has the form of a crosshead.

Courtesy of Referativnyi Zhurnal N. I. Levitskii, USSR
Translation, courtesy Ministry of Supply, England

2393. Orlov, A. A., The integration of differential equations of disturbed motion in rectangular coordinates by the small parameter method (in Russian), *Soobschch. Gas Astronom. in-ta im P. K. Shternberg*, no. 88/89, 39–53, 1953; *Ref. Zh. Mekh.* 1956, Rev. no. 2602.

The general solution of equations of celestial mechanics which is suitable within a certain distance of the initial moment is usually sought in the form of series according to the orders of the small parameter.

$$x = x^{(0)} + \sum_{n=1}^{\infty} \alpha^n \xi_n$$

$$y = y^{(0)} + \sum_{n=1}^{\infty} \alpha^n \eta_n$$

$$z = \sum_{n=1}^{\infty} \alpha^n \zeta_n$$

where $x^{(0)}$, $y^{(0)}$ are rectangular coordinates in the plane of the nondisturbed orbit. For the determination of ξ_n, η_n, ζ_n, linear nonhomogeneous equations are obtained, the left hand sides of which do not depend on n. Following Lyapunov, who used this method in a paper relating to Hill's series on the theory of Luna, author introduces, instead of ξ, η, ζ, the new complex variables

$$\varphi = \frac{1}{r^{(0)}} (\xi + i\eta) e^{-iv}, \quad \psi = \frac{1}{r^{(0)}} (\xi - i\eta) e^{iv}$$

$$\theta = \frac{\zeta}{ir^{(0)}}$$

where $i = \sqrt{-1}$, and $r^{(0)}$ and v are the radius vector, and the true anomaly of the nondisturbed Keppler orbit. The equations in variations are then written in a simple form. Differentiating the general solution of nondisturbed motion according to six arbitrary parameters, author finds the fundamental system of solutions of the system of equations for variations. Then, with the aid of the variation method of arbitrary constants, the solutions of the nonhomogeneous systems for ξ_n, η_n, and ζ_n are found.

Courtesy Referativnyi Zhurnl G. Merman, USSR
Translation, courtesy Ministry of Supply, England

2394. Preis, V. F., Certain problems of the calculation and design of chutes (in Russian), *Trudi Tulsk. mekh. in-ta* no. 7, 59–76, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2618.

The motions of punctual bodies are examined along curvilinear trajectories with a certain initial velocity under the action of the force of gravity. These arrangements, in the author's opinion (without sufficient foundation), should correspond to the motion of half-finished products and certain other components along chutes.

Courtesy Referativnyi Zhurnal N. A. Talitskikh, USSR
Translation, courtesy Ministry of Supply, England

2395. Tainov, A. I., Friction of the third type (in Russian), *Sb. nauch. tr. Belorus. politekhn. in-ta* no. 49, 109–116, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2614.

Friction is examined of rotation in the case of high kinetic couples, and a formula of the reduced coefficient of rotational friction is derived on the basis of the following assumptions: (1) At the place of contact, a flat field of small radius is formed; (2) the normal contact pressure is distributed according to the elliptic law; (3) the coefficient of sliding friction is constant over the whole field of contact, is independent of the pressure and speed of sliding, and equal to the coefficient of dry sliding.

Courtesy Referativnyi Zhurnal V. N. Geminov, USSR
Translation, courtesy Ministry of Supply, England

2396. Blitzer, L., and Wheelon, A. D., Maximum range of a projectile in vacuum on a spherical earth, *Amer. J. Phys.* **25,** 1, 21–24, Jan. 1957.

Expressions are derived for the maximum range of a projectile in vacuum on a spherical earth in terms of the ratio of kinetic to potential energy at launch. These results are combined with those for the corresponding launch angle and presented graphically. Limiting conditions are discussed, and the effect of the earth's rotation is indicated. From authors' summary

2397. Whitcomb, D. W., and Milliken, W. F., Design implications of a general theory of automobile stability and control, Instn. mech. Engrs., Prepr., 83–106, Nov. 1956.

The lateral-directional motions of an automobile are studied by means of equations of motion derived for a vehicle assumed to have yawing and side-slip degrees of freedom only, and travelling at a constant forward speed.

The equations are presented in terms of the automobile stability derivatives. The stability-derivative concept has its counterpart in airplane stability and control research.

The automobile transient and steady-state motions following the application of steering control or externally applied side forces and yawing moments are determined from the equations of motion. The responses are discussed with emphasis placed upon their principal characteristics and the identification of the significant vehicle parameters that determine them. Approximate solutions for the steady-state response are also presented.

The transient response characteristics are studied, first in terms of single-degree-of-freedom approximations, and then in terms of the two-degree-of-freedom representation. The transient motion is discussed in terms of the characteristics of a second-order dynamic system, and relations for natural frequency, damping ratio, and response time are derived. Conditions for system stability and oscillatory or nonoscillatory motion are also determined.

The results of a series of sample calculations based on the equations of motion are in an appendix. These show the general character and magnitude of the responses of a representative passenger sedan and a high-performance sports car.

The general characteristics of the transient and steady-state responses are summarized in chart form, and the influences of static margin, speed, and tire and vehicle parameters are pointed out. A brief discussion of the desirability of certain response characteristics is presented as a generalized design objective.

From authors' summary

2398. **Segel, L., Theoretical prediction and experimental substantiation of the response of the automobile to steering control,** Instn. mech. Engrs. Auto. Div., Prepr., 26–46, Nov. 1956.

Classical mechanics is applied to the automobile in order to study the lateral rigid-body motions produced by steering control. This research in the field of automotive lateral dynamics has included (1) the development of a mathematical model for a pneumatic-tired vehicle and (2) its subsequent substantiation by means of full-scale response tests made with an instrumented vehicle. A review of the theoretical work is presented together with a description of the methods used to measure the response of the test car. The resulting agreement between theory and experiment is examined, and is followed by an extensive discussion of the nature of the lateral response of the automobile to steering control.

From author's summary

2399. **Milliken, W. F., and Whitcomb, D. W., Research in automobile stability and control and in tire performance,** Instn. mech. Engrs. Auto. Div., Prepr., 3–25, Nov. 1956.

Paper is a general introduction to a series of progress reports on an experimental and analytical investigation of the fixed-control directional characteristics of automobiles, and those mechanical properties of tires used in the analysis of car stability and control. The program under consideration utilizes aeronautical and control-theory techniques in deriving and substantiating equations of motion for the automobile. In addition, a six-component tire-testing machine for static and dynamic tests on flat-road surfaces is described, and tire data for a wide range of slip and camber angles are presented.

In this initial paper an historical background of technological progress in automobile handling is given in a framework of vehicle handling in general, with particular reference to the science of airplane stability and control. This presentation enables a relative evaluation of automotive progress. The specific research objectives of the program are then examined. A summary of dynamic concepts and methods is given in Appendix II.

The paper also summarizes the results from the over-all research program and concludes that the work has led to a better physical understanding of automobile behavior, as well as to a mathematical model suitable for computing the fixed-control automobile motions. Significant comparisons are made between tire data obtained in the program and simple tire theory.

From authors' summary

2400. **Noodleman, S., Torque motors and brakes,** *Prod. Engng.* **28,** 4, 146–151, Apr. 1957.

2401. **Couling, S. A., Tooth gearing and research,** *Engineer, Lond.* **202,** 5266, 915–918, Dec., 1956.

Servomechanisms, Governors, Gyroscopics

(See also Revs. 2397, 2398, 2399, 2424)

2402. **Popov, E. P., On the use of the harmonic linearization method in automatic control theory,** *NACA TM* 1406, 6 pp., Jan. 1957. (Translation from *Doklad' Akad. Nauk SSSR (N.S.)* **106,** no. 2, 1956).

Certain restricted classes of nonlinear differential equations are examined for conditions under which their solutions may be approximated by sinusoids. Reviewer does not believe that criteria obtained are in form to be of value in automatic control theory.

L. Becker, USA

2403. **Fialko, G. M., and Milman, D. I., Calculation of the parameters of the regulators of gas concentrations according to the experimentally plotted characteristic of the regulating object** (in Russian), *Trudi Uralskogo n-i khim. in-ta* no. 2, 247–250, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2656.

Authors explain a method for determining the optimum values of adjustment parameters of an isodrome regulator, based on the given degree of damping of the regulating process and of the minimum value of the quadratic integral estimate. At the same time it was also possible to determine the form of the transition process.

As integral estimate of the quality of the process we take the integral of the sum of the squares of deviation and of the rate of change of the controlled value. Calculation of the parameters is done by the graph analytic method. There is one error: the value of the coefficient of amplification of the servomotor is omitted from the expression of the coefficient of amplification of the system.

Courtesy Referativnyi Zhurnal S. I. Bernshtein, USSR
Translation, courtesy Ministry of Supply, England

2404. **Mikhailov, F. A., The choice of the parameters of a regulator working in a system of automatic stabilization** (in Russian), *Trudi MAI* no. 41, 80–116, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2651.

Method for collecting the parameters of the linear systems of control by means of finding the conditions for the integral minimum to the square of the module of the amplitude frequency characteristic of the system or the conditions of the specific limitation of this integral. The basis for using the evaluation is shown. A method is suggested for selecting the control parameters, having regard to the limitations of the permissible deviations. Illustrative examples are given.

A. A. Krasovskii, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy of Ministry of Supply, England

2405. **Ostrovsky, G. M., Virabyan, A. O., and Voitenko, T. V., Control with influence according to the first derivative** (in Russian), *Inform. nauchn-tekhn. Byul. Nii Labor-pribor M-va mashinostr. i priborostr. SSR* no. 6, 3–39, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2650.

The effectiveness is shown of introducing influence according to the first derivative into the law of control of slowly varying productive processes. On the example of simple pneumatic regulators, two variants for effecting influence according to a derivative are examined: with the aid of the application of a delaying reverse couple and by means of a separate arrangement, which is called an advance block.

A method is given for comparing the equations of these regulators and for their elementary investigation with the aid of fre-

quency representations. Authors examine control with influence according to the first derivative as control with a time variation of the limits of proportionality between the input and output coordinate. With the aid of phase relations the effectiveness is shown of introducing influence according to the first derivative into systems with an isodrome arrangement and pure delaying, as well as of the correcting means. For control systems with a small time constant of the object compared with the time of the isodrome, the use of an advance block is recommended with a "negative derivative," the transmission function of which has the form

$$W(p) = 1 - Tp.$$

Courtesy Referativnyi Zhurnal O. N. Voropaev, USSR
Translation, courtesy Ministry of Supply, England

2406. Olesevich, K. V., The problem of evaluating the properties of the control process (in Russian), *Nauch. zap. Odessk. politekh. in-ta* **4,** 2, 73–105, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2648.

Evaluation of the property of the process of control in the form of an integral in time to the modulus of deviation of the controlled value; the integral is determined by means of previous integration of the differential equation of the system. The evaluation is calculated for the control process of the velocity of rotation of the turbine, described by the equation of the second order in the cases: linear system (servomotor of variable velocity) and relay system (servomotor of constant velocity). The control and recontrol time is also determined. Graphs are given of the relationships of the indices of the property of control to the parameters.
Courtesy Referativnyi Zhurnal A. A. Krasovskii, USSR
Translation, courtesy Ministry of Supply, England

2407. Nechaev, V. K., The calculation of mechanisms of certain limiting pneumatic regulators (in Russian), *Izv. Tomskogo politekhn. in-ta* **75,** 265–277, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2680.

A method is given for selecting the parameters of articulated mechanisms of pneumatic limiting regulators used in carburetor car engines for limiting the number of rpm in the case of a reduction of load.

Mechanisms for linking the regulator spring with a throttle valve with rigid catches (regulators of carburetors K-49, K-80) and without catches are given.

There is a misprint in the paper: $\lambda = F_H/ca^2$ should be written instead of $\lambda = F_H/ca$.
Courtesy Referativnyi Zhurnal E. V. Gerts, USSR
Translation, courtesy Ministry of Supply, England

2408. Chang, S. S. L., Transient effects of supply and connecting conduits in hydraulic control systems, *J. Franklin Inst.* **262,** 6, 437–452, Dec. 1956.

Paper analyzes the effect of transient pressure drops in long supply conduits, and in long connecting conduits. The elasticity of the conduit and the compressibility of the fluid are considered. Anthor indicates that with a long supply conduit the result is a lowered velocity saturation limit of the servomotor, and that with long connecting conduits the results are (1) a dead time in the system and (2) multiple reflections which increase the settling time of the system. That the transient pressure drop may be of importance is indicated by the fact that in 10 feet of tubing the transient pressure drop is of the order of 50 times the steady-state value.

Reviewer is pleased to find complete derivations of the formulas used in the body of paper presented in appendixes and recommends this paper to anyone concerned with hydraulic controls because of its basic nature. W. A. Wolfe, Canada

2409. Feng, T.-Y., Characteristics of unevenly underlapped four-way hydraulic servo valves, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-140, 17 pp.

Valve underlap is an effective means of stabilizing servo systems. However, the standby power loss incurred by underlap may become intolerable in high-performance systems. Author has analyzed an unevenly underlapped valve by the small-perturbation method. Use of this method is justified by examining resulting flow-pressure characteristic curves. Results show that an unevenly underlapped valve may be expected to consume substantially less standby power than an evenly underlapped valve of equivalent damping capacity. A case is illustrated in which uneven underlapping reduces standby power loss by 37%.
E. L. Foster, USA

2410. Boloban, P. E., Automatic control of steam pressure in the supply line to the turbine (in Russian), *Teploenergetika* **3,** 1, 7–13, Jan. 1956.

2411. Nemov, A. P., and Ostrovskii, Ya. M., Findings on the starting and satisfactory regulation of turbines on superhigh steam parameters (in Russian), *Teploenergetika* **2,** 11, 6–16, Nov. 1955.

2412. Shchegliaev, A. V., Flexible-band pressure regulator (in Russian), *Teploenergetika* **3,** 1, 3–7, Jan. 1956.

2413. Vazinger, V. V., Automation of compressor plants (in Russian), *Sb. statei Vses. n-i. i konstrukt. in-ta khim. mashinostr.* no. 18, 21–35, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2654.

A simplified analysis of the control of productivity of a compressor plant by means of switching the motor off and on. The relationships which characterize the efficiency of the plant and the warming up of the motor by starting voltages are indicated. Methods of protection against possible breakdowns are described.

The automation arrangement of compressor plant with asynchronous and synchronous motors is given as well as a list of the series apparatus which is included in the automation system.
Courtesy Referativnyi Zhurnal A. A. Krasovskii, USSR
Translation, courtesy Ministry of Supply, England

2414. Goroshchenko, L., Lag in instrument indication (in Russian), *Vestn. vozd. flota* no. 3, 45–52, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2693.

Graphs and nomograms are given for determining the lag of aircraft instruments with varying altitude of the aircraft dependent upon the geometrical parameters of the pipes for supplying the static pressure to the body of the instrument and the volume of the body. At vertical velocities v_y, less than 250 m/sec, the lag δp_{lag} of pressure in the body increases with decrease in the flight altitude as a result of the transition from laminar conditions of flow in pipes to turbulent ones. At $v_y > 250$ m/sec, δp_{lag} is slightly dependent upon height, and the lag of the altimeter increases with height. When diving, the pilot sees on his instruments greater height, speed, and M, and when climbing, he sees reduced values.

On a modern fighter the maximum excess of the readings attains: according to height up to 700 to 1000 m, according to speed up to 40 to 50 km/hr, and according to M up to 0.10 to 0.13. At abrupt changes in height (aerobatics, diving), the lag of the static pressure in the body of the variometer causes considerable errors in the indications of the vertical velocity (up to 50%).
Courtesy Referativnyi Zhurnal I. I. Slezinger, USSR
Translation, courtesy Ministry of Supply, England

Vibrations, Balancing

(See also Revs. 2370, 2440, 2537, 2702, 2736, 2740)

2415. Pipes, L. A., Analysis of electric circuits containing nonlinear resistance, *J. Franklin Inst.* **263,** 1, 47–55, Jan. 1957.

Voltage-current characteristic curves of nonlinear resistors under consideration can be supposed of the type: $v(i) = R_0 i + a_3 i^3 + a_5 i^5$. Paper describes reversion method [see AMR **5**, Rev. 2543] for the solution of nonlinear differential equation governing current in a general impedance in series with a nonlinear resistor. Steady-state solutions may be obtained by method of harmonic balance. Convergence problems are not investigated. In most practical cases convergence is good.

Methods are illustrated by analysis of a circuit containing a linear inductor in series with a nonlinear resistor. Most interesting case is circuit activated by harmonic potential and large bias potential. It is shown that increase of the bias potential produces an increase in effective resistance of the circuit.

W. L. Esmeijer, Holland

2416. Klotter, K., On some concepts of nonlinear oscillation theory, *J. aero. Sci.* **24**, 1, 78–79 (Readers' Forum), Jan. 1957.

A comment on a paper by F. H. Chauser discussing nonlinear systems [AMR **9**, Rev. 3847] points out: (1) The phenomenon of the sudden changes in amplitudes of forced oscillation, the so-called "jump phenomenon," bears no relation to hysteresis. (2) The terms "autonomous" and "non-automomous" are used differently from established usage. These new usages should be pointed out by the author. (3) The terms "hard" and "soft" as applied to springs should refer to spring rate, not change in spring rate. "Hardening" and "softening" are better terms for the latter.

F. E. Reed, USA

2417. Atkinson, C. P., and Heflinger, L. O., Subharmonic and superharmonic oscillations of a bilinear vibrating system, *J. Franklin Inst.* **262**, 3, 185–190, Sept. 1956.

Paper reports qualitative experiments with a second-order nonlinear vibrating system which is damped and sinusoidally forced. Nonlinearity is in the spring constant which is taken "bilinear," that is, changes abruptly from one fixed value to another at a given amplitude of response. Experimental results conform with theory. It is pointed out that the system can be bracketed by two linear systems, one which approximates it at small, the other at very large, response amplitudes. The natural frequencies of these two linear systems define a frequency range which can be used to characterize some of the behavior of the nonlinear system.

R. Drenick, USA

2418. Biorci, G., Free vibration of nonlinear systems with negligible damping (in Italian), *Ingegnere* **30**, 8, 759–764, Aug. 1956.

An approximate method is proposed for solving, graphically and numerically, differential equations of the type $y'' = f(x, y, y')$. This method is applied to free vibrations of nonlinear elastic systems with one degree of freedom, and in particular to nonlinear elasticity of rubber type. Method proposed is simple and proves to be exact enough for technical problems, but reviewer thinks it would be interesting to know an estimate of its error.

H. F. Long, Argentina

2419. Kabulov, V. K., Graphical investigation of the elastic-plastic oscillations of a system with one degree of freedom, when the stress-strain diagram is represented in the form of a broken line (in Russian), Reports of Academy of Sciences of Uzbekistan SSR. no. 7, 11–14, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3125.

The graphical plotting of the "displacement-velocity" diagram (*D-V* diagram) is described for the case of free oscillations of a system with one degree of freedom; it is assumed that the material has linear hardening. For the elastic section of the elongation-compression diagram, the *D-V* diagram does not differ from the diagram suggested by I. M. Rabinovich [Collection: "General strength and stability of constructions with the action of an eruptive load," M. Gosstroiizdat, 1944]. Having assumed the displacement and velocity for the end of the elastic stage as initial conditions of the second stage, the plotting is effected in the plan similar to the investigation on the first section. The plotting on the third, etc., sections is performed in a similar way, including the unloading section.

Views on the application of the *D-V* diagram to the investigation of the forced oscillations of elastic-plastic systems are given.

Courtesy Referativnyi Zhurnal N. I. Bezukhov, USSR
Translation, courtesy Ministry of Supply, England

2420. Zoller, E., Grammel's method for the solution of eigenvibration problems (in German), *Ing.-Arch.* **24**, 6, 401–411, 1956.

The method of Grammel, for the analysis of vibration problems, calls for a duality transformation of the differential equations, as established by the aid of Hamilton's principle. Method is applied to some simple examples of beam vibration. The method presented is a new approach to the introduction of the Grammel procedure, using the Hamilton principle. It can be used for one-dimensional. one-term vibration models. Comparison with the Rayleigh-Ritz method is given. It is shown that in most cases the Grammel method is better suited for the special vibration problems considered.

B. Langefors, Sweden

2421. Suppiger, E. W., and Taleb, N. J., Free lateral vibration of beams of variable cross section, *ZAMP* **7**, 6, 501–520, Nov. 1956.

A clear discussion of the theory of normal modes of a beam with natural end conditions is given. Calculations are included for beams with exponentially varying cross section.

C. Ablow, USA

2422. Grigolyuk, E. I., Nonlinear oscillations and stability of slanting rods and envelopes (in Russian), *Bulletin of Academy of Sciences SSSR, Section of technical sciences* no. 3, 33–68, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3109.

The natural and forced oscillations are examined in the case of finite displacements of slanting rods of sinusoidal form and of slanting envelopes of rotation, defined according to the surface of the sphere and of the cone in the case of axial-symmetrical deformation, and also particular cases of a flat rod and of a round plate. The attachment of the edges is assumed to be elastic; the numerical results are given for envelopes in the case of clamped, fixed, freely resting and rigidly resting edges; the data given for rods enable the degree of the elastic attachment to be estimated in an axial direction. It is assumed that the objects investigated are conservative systems.

The solution of the equation of motion of a slanting rod $\Phi_w = 0$ is approximated in the form

$$w(x, t) = \sum_{j=1}^{n} W_j(t)\, w_j(x)$$

the coordinate functions $w_j(x)$ are given corresponding to the boundary conditions; for determining the functions $W_j(t)$ by Bubnov's method, a system of nonlinear ordinary differential equations of the second order is obtained

$$\Phi(w, w_j) = 0 \qquad (j = 1 \ldots\ldots n) \qquad [*]$$

a similar method is also used in the investigation of envelopes as well.

The numerical results given relate to the solution of the problem in the first approximation ($n = 1$). The amplitude of the forced oscillations which occur with a frequency of the external load ω is determined from the condition of orthogonality of the left side of the equation of motion [*] with the function $W_1 = W \cos \omega t$ in the course of a quarter of the oscillation period. In the absence of an external load the frequency is determined of the acutal (nonlinear) oscillations dependent upon the amplitude of the oscillation and parameter m (in the case of rods $m = 4l/Fb^2$, where l is the moment

of inertia, F the area of the cross section, h the rise of the elevation of the arc; in the case of envelopes $m = D/E\delta h^2$, while D is the cylindrical rigidity, δ the thickness, h the height of the elevation of the envelope). These relationships are given for rods, for a spherical envelope, and a circular plate by graphical means; for plotting the corresponding diagrams for the conical envelope all the necessary data are given. It is pointed out that the precise determination of the period of actual oscillations is reduced to the solution of elliptic integrals. By this means the periods of natural oscillations of a prismatic rod and round plate are calculated. A comparison is made of the precise and approximate values, indicating the small degree of error of the approximate method employed.

Data necessary for the investigation of the stability of motion are given in the form of tables: the steady values of the elastic force and potential energy, and also the values W_1 at which the potential energy of the system is equal to one of its steady values. This investigation with plotting of the integral curves in the phase plane dependent upon the oscillation system of energy is made at various values of m for rods.

Courtesy Referativnyi Zhurnal N. A. Alumyae, USSR
Translation, courtesy Ministry of Supply, England

2423. Rasskazovskii, V. T., Approximate calculation of frequencies and forms of free oscillations of a rod with an elastically fixed contour (in Russian), *Reports of the Uzbekistan SSR*, no. 5, 11–14, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3120.

The problem indicated in the title is reduced to an integral equation, the nucleus of which is expanded into a series according to the real functions. E. I. Grigolyuk, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2424. Bishop, R. E. D., The analysis of vibrating systems which embody beams in flexure, *Instn. mech. Engrs. Proc.* **169**, 51, 1031–1050, 1955.

Paper presents tables of receptances (dynamic flexibilities) as functions of frequency for end excitation of undamped uniform beams in flexure with all possible end conditions. Functions, but not tables, are given for interior points. Application is made to vibration problems, mainly frequency equation; mention of forced vibration is included.

Reviewer believes exposition and algebra are overly complex to demonstrate that method is "most convenient." Use of left hand coordinate system is unfortunate. Functions presented are simple combinations of elementary functions. Discussion and author's reply is very valuable as demonstrating the state of art. Forthcoming book by author and D. C. Johnson will be useful to practitioners. R. Plunkett, USA

2425. Inoue, N., A technique for computing natural frequencies of trapezoidal vibrators, *J. aero. Sci.* **24**, 3, 239–240 (Readers' Forum), Mar. 1957.

Flexural vibrations of a cantilever beam of uniform depth having a linear taper in planform are investigated. Using a perturbation scheme, author obtains a first-order correction, valid for small angles of taper, to the frequencies of the uniform beam.

H. Deresiewicz, USA

2426. Flodin, J., Fixation of beams in vibration calculations, *J. Amer. Soc. nav. Engrs.* **69**, 1, 163–164, Feb. 1957.

2427. Lassiter, L. W., Hess, R. W., and Hubbard, H. H., An experimental study of the response of simple panels to intense acoustic loading, *J. aero. Sci.* **24**, 1, 19–24, 30, Jan. 1957.

The dynamic stress response was determined as a function of frequency for both flat and singly curved unstiffened panels with riveted edge conditions, material 2024-T3 aluminum alloy. The response was affected by the input pressure level of the excitation as well as the backing material of the panel. The response of the panels to random load was essentially sinusoidal.

Noise spectra were measured near the tailpipe of a jet engine. The stress in the panels at a number of selected locations in the noise field of this jet engine was measured and calculated. The agreement was good.

Panel fatigue characteristics were determined under discrete frequency acoustic loading. Fatigue life depends largely on the sound level. J. Schyve, Holland

2428. Herrmann, G., The influence of initial stress on the dynamic behaviour of elastic and viscoelastic plates, *Publ. int. Assn. Bridge struct. Engng.* **16**, 255–294, 1956.

Author first derives from Biot's general three-dimensional theory of elasticity of a body under initial stress the equations of motion of an initially stressed plate, which imply Saint-Venant equations of a plate as a special case. For this purpose proper assumptions are introduced as to displacements, and Hamilton's principle is used. Necessary further simplifications are pointed out. The equations of motion are solved for the problem of vibrations of a viscoelastic rectangular plate, simply supported along all four edges and subjected to initial uniformly distributed uniaxial thrust. Neglecting the damping, the additional effect of the weight of the plate and that of a free edge is discussed. Particularly, the influence of the aspect ratio of the plate on the deflections and on the frequencies of vibration is analyzed, and the connection to the stability problem of the plate is worked out.

F. Engelmann, Germany

2429. Nagaraja, J. V., A note on vibration of cantilevered trapezoidal plates, *J. Instn. Engrs., India* **37**, 3, 213–215, Nov. 1956.

2430. Bergmann, L., Experiments with vibrating soap membranes, *J. acoust. Soc. Amer.* **28**, 6, 1043–1047, Nov. 1956.

For experiments with vibrating soap films it is necessary to obtain such films of even thickness. Author describes an apparatus which forms them by rotation. The soap membrane is set in vibration by an electrodynamic loudspeaker. The vibrations are made visible by reflected light. It is astonishing to see how simple an apparatus can be which shows the natural vibrations in circular and square soap films and in various frequencies in such an impressive manner as the added photos affirm.

G. Brandes, Germany

2431. Leonov, M. Ya., and Bezpalko, L. A., Investigation of the stability of a shaft, rotating with supercritical velocity (in Russian), *Scientific Reports of the Institute of Mechanical Engineering and Automatics of Acad. Sciences USSR* **4**, *Mechanical Engineering Series* no. 3, 12–32, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3119.

Oscillations are examined of a rotating shaft with one centered disk with the absence of gyroscopic effect. The stability in small steady motion beyond the critical velocity is investigated on the assumption of finite rigidity of the shaft to torsion. As opposed to the usual solution, in this case a band of instability, having a width of an order of $\omega_0(\epsilon/\rho)^{3/2}$ and departing to the region of large frequencies with increase of the torsional rigidity (ω_0 is the frequency of the actual bending oscillations, ρ is the radius of inertia of the disk, ϵ is the excentricity of the disk). In this part damping is not taken into consideration.

Further, on the basis of the known assumption of the link of internal friction with the phenomenon of elastic hysteresis, the growth of energy of free oscillations of a rotating shaft is determined. For the case when the area of the hysteresis loop is proportional to the third degree of amplitude of deformation, the growth of the energy proportional to the third degree of amplitude of the free oscillations does not depend upon the frequency of rotation

for a vertical shaft with a balanced disk and is a monotonously increasing function of the frequency for a horizontal shaft.

These results however are insufficient to judge the stability (instability) of motion of the shaft.

Courtesy Referativnyi Zhurnal V. V. Bolotin, USSR
Translation, courtesy Ministry of Supply, England

2432. Gurov, A. F., Combined aero-propeller-shaft vibrations (in Russian), *Trudi MAI* no. 40, 1–72, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1706.

A method of calculation involving the dynamic rigidity values of the propeller and shaft is presented. The dynamic rigidity of the propeller is determined by calculation from its anti-resonance and resonance frequencies. The first are determined for the untwisted blade, vibrating in the plane of least rigidity, by successive approximations (for the higher modes, the condition of orthogonality is applied). In determining the resonance frequencies, the hinge axis of the blade is assumed to coincide with the shaft axis, the amount of torsion (twist) being estimated by consideration not only of the moments of the elastic vibrations of the blade, but also of the moments of the transient vibration of the propeller as a whole, applying a number of simplifying assumptions. Schemes are given for calculating the coefficients allowing for the influence of centrifugal forces on the frequency of the rotating blade, and the values of such coefficients are given.

A detailed calculation scheme and examples of the calculation of the dynamic rigidity of the propeller and the associated vibration frequencies of the propeller-shaft system are presented.

Courtesy of Referativnyi Zhurnal V. K. Zhitomirskii, USSR
Translation, courtesy Ministry of Supply, England

2433. Suslov, V. P., Determination of the critical rpm of ship propeller shafts (in Russian), *Trudi Leningr. korablestroit. in-ta* no. 12, 213–228, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2639.

The graphical method of determining the first critical rpm of multibearing shafts represents a variant of the graphical method for determining the frequency of natural transverse fundamental oscillations of undivided slitted shafts [see A. P. Filippov, "Methods of calculating structures for oscillations," GTTI, 1936]. For the shafts of vessels the first critical angular velocity is important. The graphs for determining the calculated coefficients are plotted. The use of graphs is illustrated by examples.

Courtesy Referativnyi Zhurnal V. M. Starzhinskii, USSR
Translation, courtesy Ministry of Supply, England

2434. Obmorshev, A. N., Oscillations of linked systems with two degrees of freedom (in Russian), Raschety na prochnos'. zhestkos'. ustoichivos' i kolebaniya, 259–270, Moscow, Mashgiz, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2637.

2435. Hanson, P. W., and Tuovila, W. J., Experimentally determined natural vibration modes of some cantilever-wing flutter models by using an acceleration method, *NACA TN* 4010, 46 pp., Apr. 1957.

Three-dimensional views are presented of the first three natural vibration mode shapes of ten cantilever-wing models. A table of normalized deflections at six spanwise and five chordwise stations is included for each mode. These mode shapes were measured by a rather unique experimental technique using grains of sand as accelerometers. The technique, which is particularly suited for measuring mode shapes of small wing models, is described and some of the difficulties likely to be encountered in applying the technique are discussed. From authors' summary

2436. Leone, P. F., Mechanical stability of a two-bladed cantilever helicopter rotor, *J. aero. Sci.* **23**, 7, 633–638, July 1956.

Undamped coupled natural vibrations of a helicopter rotor are analyzed. The hub is mounted on isotropic elastic supports in the horizontal plane, and the elastic blades employ fixed root attachments. With generalized coordinate theory a frequency equation is derived, containing three hub and rotor blade mass and stiffness parameters. These are numerically determined for a typical non-uniform rotor blade.

The similarity with the case of stiff blades mounted on hinges offset from the rotor center is shown. The elastic potential energy of the rotor blade can be increased by employing root tension straps. The increase in stationary natural frequency of a uniform rotor blade due to such straps is calculated.

J. Hult, Sweden

2437. Ramsay, J. W., Aspects of ship vibration induced by thin propellers, *Trans. Instn. nav. Arch. Lond.* **98**, 4, 410–431, Oct. 1956.

The character of vibration in fast turbine-driven ships depends partly on the magnitude and frequency of the forces imposed upon it by the propellers, according to their geometry and location; and partly upon the elastic properties of the hull structure. These two aspects are discussed with particular reference to the author's experience in twin-screw warships.

The forces exciting vibration are believed to be predominantly hull pressure forces in the vertical direction and mixed wake forces in the athwartships direction. Some preliminary theoretical and experimental results are given with regard to the magnitude of the pressure forces.

The response of the hull to such forces is discussed in the light of a vibration generator survey of a destroyer in harbor and calculations of the first five natural frequencies of vertical flexural vibration. From author's summary by K. Klotter, USA

2438. Mindlin, R. D., Simple modes of vibration of crystals, *J. appl. Phys.* **27**, 12, 1462–1466, Dec. 1956.

Author discusses vibration of crystal rectangular parallelepipeds using three-dimensional elasticity equations. Solutions are obtained valid for certain classes of crystals, orientations, and length-ratios of edges. Face-mode vibration of thin crystal plates is similarly treated using equations of generalized plane stress. Author suggests that results may be advantageously utilized for experimental measurement of elastic constants under piezoelectric excitation. A. M. Wahl, USA

Wave Motion in Solids, Impact

2439. Pursey, H., The launching and propagation of elastic waves in plates, *Quart. J. Mech. appl. Math.* **10**, 1, 45–62, Feb. 1957.

Paper is written for people thoroughly familiar with the theory of wave propagation. Expressions are deduced for displacements and stresses in a plate subject to boundary stresses varying with time in the form of Hankel and Fourier transforms. Approximate expressions are derived for group velocities, and tables are supplied by which these and the corresponding amplitudes can be calculated for thicknesses up to a certain value. Unfortunately, the procedure is presented in a form suitable only for the specialist. J. Solvey, Australia

2440. Oliver, J., Elastic wave dispersion in a cylindrical rod by a wide-band short-duration pulse technique, *J. acoust. Soc. Amer.* **29**, 2, 189–194, Feb. 1957.

Paper is concerned with experiments on dispersion of elastic waves in 19-ft cylindrical steel rod of 1-in. diam. Author claims to have extended the ratio of wave length to diameter to smaller values. Classical Pochhammer theory for ideal elastic cylinder of infinite length is unable to account for the effects at the ends of a finite rod. Some interesting points are raised in the paper regarding discovery of "waves of a resonant nature associated with the ends of the rod." But reviewer believes that clarification is

needed both in precise explanation of results and in theoretical analysis. R. E. D. Bishop, England

2441. Deresiewicz, H., Plane waves in a thermoelastic solid, *J. acoust. Soc. Amer.* **29,** 2, 204–209, Feb. 1957.

Paper considers the propagation of plane waves in an isotropic, thermoelastic solid and shows that there may exist a pure elastic transverse wave and two coupled thermoelastic waves, one mainly dilatational and slightly thermal in character (E), the other slightly dilatational and predominantly thermal (T).

The complex secular equation relating the components of a complex wave number to the frequency is derived, and the phase velocity and specific energy loss for each type of wave are calculated for certain forms of wave number and, in general, for the case of small thermoelastic coupling. These results indicate that the E-wave experiences adiabatic conditions in the medium at low frequencies and isothermal conditions at high frequencies; the associated specific loss varies from zero at zero frequency to a maximum at the frequency of relaxation of thermal currents and approaches zero again as the frequency tends to infinity. For the T-wave, the phase velocity increases monotonically with frequency, while the associated specific loss is finite for all frequencies, passes through a single minimum.

The frequency of maximum loss for an E-wave in aluminum is shown to be 10^{11} cps.

Unfortunately, author seems only partially to have taken the opportunity of discussing the questions to which his analysis gives rise. He appears to consider the following view as widely held and attributable in first instance to Laplace: to an elastic wave, a medium offers isothermal conditions at sufficiently low frequencies, and adiabatic conditions at sufficiently high frequencies. He may well be right in thinking this thesis widespread but reviewer can only find it implicit in the discussions referenced, though these may be arraigned as misleading since comparison is made between period of wave and time for attainment of thermal equilibrium. It is correct and important to point out that the appropriate comparison is between wave length λ and the distance over which thermal equilibrium is attainable during the period of a wave, say L, and presumably a few atom spacings representing a few mean-free-path lengths of a phonon. It follows that, in a continuous medium,

(1) when $\lambda \gg L$, E-waves are propagated adiabatically,
(2) when $\lambda \sim L$, there will be a maximum specific loss,
(3) when $\lambda \ll L$, E-waves are propagated isothermally.

This paper draws attention to these possibilities but omits to mention that only (1) can fulfil the conditions necessary for the theory to be a valid approximation for a physical solid, viz., specimen dimensions $\gg \lambda \gg$ atomic spacing.

M. J. P. Musgrave, England

2442. Fettis, H. E., On the evaluation of two functions occurring in Maslen and Moore's theory of strong transverse waves in a circular cylinder, *J. aero. Sci.* **24,** 1, 64–65 (Readers' Forum), Jan. 1957.

2443. Kutsenko, S. M., The dynamic action of locomotive wheels on rails (in Russian), *Trudi. Semin. teor. Mash. Mekh. in-ta mashinoved. Akad. Nauk SSSR* **15,** 57, 5–26, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3201.

Determination of the vertical dynanic pressures of locomotive wheels upon rails is effected, having regard to the elastic yielding of the track. It is assumed that the line of rolling is not a circle, the rectilinear form of the track in a vertical direction is disturbed by the irregularities which occur at the joints, and the rail track works as a beam on an elastic base with a linear change of resistance. The equation of motion is set up for one leading wheel loaded by the spring-mounted mass. A solution is given for the case when the curve of wheel irregularities enables expansion into a trigonometric series to be made or is given in tabular form.

Numerical examples and graphs are given which show that the dynamic pressure of locomotive wheels on the rails depends upon the properties of the rail track and increases considerably with deterioration of its qualities. K. S. Kolesnikov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2444. Greco, L., Notes on mathematical wave theories and the necessity of experimental research (in French), *Houille blanche* **11,** 4, 563–578, Oct. 1956.

Elasticity Theory

(See also Revs. 2419, 2441, 2443, 2460, 2463, 2471, 2472, 2473, 2474, 2483, 2486, 2487, 2489, 2504, 2514)

2445. Rongved, L., Dislocation over a bounded plane area in an infinite solid, ASME Ann. Meet., New York, N. Y., Nov. 1956, Pap. 56–A–53, 3 pp.

An elegant application of potential theory such as used by Mindlin [AMR **7,** Rev. 2418] leads to a closed solution of the problem of an infinite isotropic elastic solid with a constant displacement discontinuity over a rectangular area. The Papkovitch functions are determined for an arbitrary displacement discontinuity over any bounded plane area. W. Freiberger, USA

2446. Dlugach, M. I., Method of forces applied to the theory of elasticity, *Ukr. appl. Mech.* **1,** 1, 83–97, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3041.

A solution is given of the two-dimensional problem of the theory of elasticity, based on the resolution-forces method with the lattice method. The method for determining the displacements in problems of the theory of elasticity is shown in a form similar to More's method in constructional mechanics of rod systems. When determining the displacements in a statically indeterminate system, the virtual state may be referred to a statically determined system. On this basis the author assumes that in the virtual state the stress function and its normal derivative on the contour retain the given values, and inside the region the stress function is equal to zero. The suggested method enables the mixed problem of the theory of elasticity to be solved, and also the tensile state of multilink regions. The characteristic single states are adduced, and expressions for the setting up of a system of equations are developed. The method is illustrated by the results of calculations of certain types of girder walls (clamped girder plates wall, girder plates of two different materials, girder plate under the action of force inside the region) of an extended rectangular plate with one and two square orifices, and also of a channel section flat frame with wide elements.

Courtesy Referativnyi Zhurnal P. M. Varvak, USSR
Translation, courtesy Ministry of Supply, England

2447. Mossakovskaya, S., The stress function of elastic bodies with triaxial orthotropy (in Russian), *Byul. Polsk. Akad. Nauk Otd. IV,* **3,** 1, 3–6, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1605.

The general problem is examined of the elastic equilibrium of an orthotropic body of arbitrary form, deformed or distorted by forces distributed over its surface. Starting from the equations of equilibrium of an orthotropic body for its displacement projections, author demonstrates that, in the general cases, these displacement projections can be expressed in the form of fourth-order derivatives of three functions $\varphi_i(x, y, z)$ $(i = 1, 2, 3)$, and gives the ex-

pressions for such displacements. The functions φ_i satisfy the equation

$$\Delta_1\Delta_2\Delta_3\varphi_i - B_4^2\,\Delta_1\frac{\partial^4\varphi_i}{\partial y^2\partial z^2} - B_5^2\,\Delta_2\frac{\partial^4\varphi_i}{\partial x^2\partial z^2} - B_6^2\,\Delta_3\frac{\partial^4\varphi_i}{\partial x^2\partial y^2} + 2B_4B_5B_6\frac{\partial^6\varphi_i}{\partial x^2\partial y^2\partial z^2} = 0$$

in which Δ_k are the differential operators of the second order, in the form

$$\Delta_k = a_k\frac{\partial^2}{\partial x^2} + b_k\frac{\partial^2}{\partial y^2} + c_k\frac{\partial^2}{\partial z^2} \qquad (k = 1, 2, 3)$$

and a_k, b_k, c_k, B_4, B_5, B_6 are constant coefficients depending on the elastic constants of the material. For the particular case, the equations of the orthotropic body furnish the known formulas of B. G. Galerkin, linking the displacement projections of the isotropic body with three biharmonic functions.

Courtesy of Referativnyi Zhurnal S. G. Lekhnitskii, USSR
Translation, courtesy Ministry of Supply, England

2448. Cowan, H. J., Torsion in reinforced and prestressed concrete beams, *J. Instn. Engrs. Austral.* **28,** 9, 235–240, Sept. 1956.

Critical survey of literature on the subject. The principles discussed are readily applied for practical design of plane, reinforced, or prestressed-concrete sections subject to torsion or combined bending and torsion. G. Kazinczy, Sweden

2449. Borisov, M. D., Torsional rigidity of component thin-wall rods with elastic strips (in Russian), *Trans. Leningrad Textile Institute* no. 6, 109–118, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3152.

A method is given for the torsional calculation of component thin-wall rods, connected to one another by strips according to the formulas for open profiles, but by replacing the torsional rigidity and bending-torsional characteristic by the values introduced.

A formula is derived for the introduced torsional rigidity for a coupled thin-wall rod; it is shown how this formula should be transformed for a rod made up of four angle brackets; in the particular case when the fractures in the contour fuse into one, this formula determines the torsional rigidity of a thin-wall rod, reinforced by strips.

A numerical example is given of the calculation of a rod, reinforced by two H-sections, and clamped by the torsional angles at both ends. D. V. Bychkov, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2450. Blokh, V. I., The torsion of elastic isotropic cylinders by surface forces in the presence of axial symmetry (in Russian), *Trudi Kharkovsk. avtomob.-dor. in-ta* no. 16, 159–173, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1608.

Solutions are given for the following problems on the torsion of axially-symmetrical bodies, with similarly, axially symmetrically distributed, surface forces: torsion of hollow and solid, finite, infinite, and semi-infinite cylinders by the action of (tangential) stresses (axially-symmetrically) distributed over the cylindrical envelopes; torsion of an infinite layer, a hemi-space, and a space with a cylindrical cavity, by forces acting on the surface of the cavity; torsion of a two-dimensional layer and a hemi-space by forces distributed over the boundary planes; torsion of a solid cylinder of finite length by forces applied at the ends. A method is likewise indicated for the solution of problems of torsion by forces applied to the flat sides of a hollow cylinder of finite length, and of a semi-infinite, two-dimensional layer and a hemi-space with cylindrical cavities.

In these calculations, the known method is used of seeking the displacement $u\theta/\theta$ and stresses

$$\sigma_{r\theta} = \frac{E}{2(1+\theta)}\left(\frac{\partial u_\theta}{\partial r} - \frac{u_\theta}{r}\right), \qquad \sigma_{z\theta} = \frac{E}{2(1+\theta)}\frac{\partial_u\theta}{\partial z}$$

in the form of series of the type

$$u_\theta = \frac{2(1+\theta)}{E}\left[\Sigma(c_{1n}e^{\gamma n z} + c_{2n}e^{-\gamma n z})J_1(\gamma_n r) + \Sigma(c_{3n}e^{\gamma n z} + c_{4n}e^{-\gamma n z})K_1(\gamma_n r)\right]$$

(with real or imaginary γ_n), or for infinite bodies in the form of the corresponding Fourier integrals; in which regard, for determining the unknown coefficients or functions of u_θ from the boundary conditions, the boundary values of the stresses are likewise represented by series or by corresponding integrals of the Fourier type (Fourier, Fourier-Bessel functions, and the like).

Courtesy of Referativnyi Zhurnal P. P. Kufarev, USSR
Translation, courtesy Ministry of Supply, England

2451. Trostel, R., Transient thermal stresses in a hollow sphere (in German), *Ing.-Arch.* **24,** 6, 373–391, 1956.

Paper presents an investigation of the stress condition arising in a hollow sphere from a transient temperature field. The inner and outer surfaces are subjected to time-dependent temperatures which have any axisymmetric space distribution. First, the temperature fields are defined, and then a study is made of thermal stresses in a thick hollow sphere. In the absence of surface tractions, the so-called thermoelastic deformation potential is developed. Solutions for some spherically symmetric cases are deduced and approximate formulas given. Finally, several hints on the problem of thermal stresses in spherical shells are presented.

W. H. Hoppmann, II, USA

2452. Lomakin, V. A., Elastic-plastic equilibrium of a sphere in a nonsteady temperature field (in Russian), *Appl. Math. Mech.* **19,** 2, 244–248, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3086.

An examination is made of the elastic-plastic equilibrium of a sphere (in the presence of strengthening) on the basis of the theory of small elastic-plastic deformations. A detailed analysis is made of the problem of stresses in a cooled sphere on the condition that the temperature of the surface of the sphere at the initial instant is reduced to zero and, further, remains equal to zero. The residual stresses are calculated. L. M. Kachanov, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2453. Copeland, R. E., Shrinkage and temperature stresses in masonry, *J. Amer. concr. Inst.* **28,** 8, 769–780, Feb. 1957.

2454. Budyka, I. N., Problem of calculation of a disk without a central hole (in Russian), *Proc. Leningrad Polytechnic Institute* no. 177, 88–100, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3078.

An example is included of the use of known equations and tables of coefficients for calculation of stresses in the disk without a central hole, the inner portion of a disk of constant thickness, the external portion of a conic profile. The calculation of the disk is effected by two known calculation methods.

Courtesy Referativnyi Zhurnal V. G. Popkov, USSR
Translation, courtesy Ministry of Supply, England

2455. Shevlyakov, Yu. A., Concentration of stresses about a circular orifice in a spherical bottom (in Russian), *Reports of Acad. Sciences of Ukr. SSSR* no. 1, 46–49, 1955; *Ref. Zh. Mekh.* 1956, no. 3059.

A solution is given of the problem of stresses in a sloping spherical envelope, weakened by a circular orifice in the center

with a small radius r_0; the equation of V. Z. Vlasov is used ["General theory of envelopes," Gostekhizdat, 1949]. Boundary conditions at the orifice: normal force and bending moment are lacking, and the transverse force is equal to the given value. The problem is solved by the method of the function of a complex variable; a formula is obtained for a normal annular force on the contour of the orifice. V. G. Rekach, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2456. Rzhanitsyn, A. R., Nonelastic deformations of systems in time (in Russian), Investigations in building mechanics, 5–23, Moscow, State Publishing House for Building and Architecture, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 3098.

Ideas which were set out by the author in the monograph "Some problems of the mechanics of systems deformed in time" [Gostekhizdat 1949] are developed, in the sense of the theory of the Boltzmann-Volterra reaction. A general solution is given for an isotropic body with the aid of the operational method. The case is examined of nonlinear deformation, and the solution of certain concrete problems is given. A. P. Bronskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2457. Kochetov, G. M., Results of tensiometric measurement of forces acting on turbine blades (in Russian), *Teploenergetika* **2**, 12, 8–14, Dec. 1955.

Experimental Stress Analysis

(See also Revs. 2457, 2499)

2458. Grigoriev, A. M., and Bulygin, V. Ya., On the application of photoelasticity to determining the stress conditions of drains and slopes (in Russian), *Trudi Kazansk. khim.-tekhnol. in-ta* no. 18, 66–71, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1661.

Authors attempt the investigation by photoelastic methods of the strength and stability of slopes, canals, and drains for the case of mechanical excavation of the soil. During their researches, authors assume the soil to be a homogeneous, elastic medium, and conduct their caclulations on the basis of the theory of maximum tangent stresses.

In the equation for mechanical similarity presented by the authors, $T_1 = \beta T$, where T_1 is the stress in the soil, T the corresponding stress in the model, and β the ratio of the external pressures applied to the soil and the model, respectively. There is, however, no factor representing the geometrical similarity between the soil and the model. By transformation, authors arrive at the following final form of this equation

$$\sigma_n = \sigma \tau_n / \tau_{2,3}$$

where σ_n = breakdown pressure on the soil, σ corresponding pressure on the model, τ_n limiting strength of the soil in shear, $\tau_{2,3}$ maximum tangent stresses in the model corresponding to the isochromatic stress of the second or third order.

Thus, according to the authors, the breakdown pressure on the soil depends on the value of the denominator $\tau_{2,3}$.

Courtesy of Referativnyi Zhurnal S. P. Shikhobalov, USSR
Translation, courtesy Ministry of Supply, England

2459. Monismith, C. L., and Clough, R. W., Horizontal displacements in a flexible two-hinged arch, *Proc. Soc. exp. Stress Anal.* **14**, 1, 131–136, 1956.

Paper presents the results of an investigation to determine experimentally the magnitude of the horizontal displacements developed in a model arch rib under an unsymmetrical loading, and to study the effects of these displacements on the internal force components in the arch. In addition, the vertical displacements and bending strains in the rib were also measured. The experimental results are compared with the results of a numerical procedure which takes account of horizontal displacements, and good agreement is indicated. The experimental results are also compared with a few of the existing "deflection theories" for arches. For the particular arch and particular condition of loading studied, the results indicate that to neglect the horizontal displacements leads to an appreciable error in bending moments (on the unsafe side). From authors' summary

2460. Wetterstrom, E., Alignment fixture for calibration of photoelastic fringe value by tension, *Proc. Soc. exp. Stress Anal.* **14**, 1, 53–54, 1956.

Rods, Beams, Cables, Machine Elements

(See also Revs. 2380, 2421, 2422, 2423, 2425, 2431, 2432, 2440, 2448, 2450, 2490, 2491, 2496, 2509, 2515, 2541, 2727)

2461. Gross, W. A., and Li, J. P., Beams of uniform strength subjected to uniformly distributed loading, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–9, 4 pp.

A beam of uniform strength subjected only to bending has the same flexural stress at any cross section which thus varies along the length of the beam. For a given form of loading the variation of the cross section has to be determined. This paper considers beams of rectangular cross section with (a) constant height, (b) constant width, uniformly loaded along the axis of the beam, on the assumption that elementary beam theory is valid. Cantilever, simply-supported, and fixed beams are considered. The method used in (b) yields the result in the form of an integral which has to be evaluated numerically, and it is pointed out that the procedure can be applied to beams of constant ratio of width to height and beams of circular cross section. Some numercial results are worked out. J. Fulton, Scotland

2462. Sharmazanashvili, A. Kh., On the calculation of elastically-supported beams without using Winkler's hypothesis (in Russian), *Trudi Gruz. politekh. in-ta* no. 27, 38–44, 1953; *Ref. Zh. Mekh.* 1956, Rev. no. 1695.

The curvilinear contour of the diagram of pressures transmitted by the beam to the elastic support is substituted by a stepped profile. The sinking of the supports under the stepwise-variable, distributed load is calculated from the standard theory of elasticity. The beam flexures, whether from the applied loads or due to the reaction of the supports with stepwise-variable intensity, are determined from the universal equation of the elastic line. The settling of the foundations and the beam flexures are then equalized at the corresponding points. The resulting system of equations in conjunction with the equations of equilibrium enable the insensities of the pressures to be determined for each step or stage.

In general, the work is a slightly different exposition of the method of B. N. Zhemichkin [Raschet balok ma uprugom poluprostranstve i poluploskosti, 1937. Izd-vo VIA].

Courtesy of Referativnyi Zhurnal P. I. Klubin, USSR
Translation, courtesy Ministry of Supply, England

2463. Sorokin, A. S., On the calculation of elastically supported beams (in Russian), *Nauch. tr. Dnepropetr. metatalurg. in-ta* no. 32, 272–278, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1696.

The system already known from the theory of the flexure of elastically supported beams, of integral-differential equations

$$EIu^{IV}(x) = q(x) - p(x)$$

$$u(x) = \frac{2}{\pi E_0} \int_{-l}^{+l} p(\xi) \ln \frac{1}{(x-\xi)}\, d\xi + C$$

is reduced to a single Fredholm integral equation of the second kind with a continuous nucleus

$$p(x) = \frac{A_1 + A_2 x}{\sqrt{l^2 - x^2}} + A_3 \sqrt{l^2 - x^2} + A_4 x \sqrt{l^2 - x^2} - \\ - \frac{k}{4\pi^2} \int_{-l}^{+l} \Phi(x, \xi) [q(\xi) - p(\xi)] \, d\xi$$

in which

$$\Phi(x, \xi) = (x - \xi)^2 \ln \frac{l^2 - x\xi + \sqrt{l^2 - x^2}\sqrt{l^2 - \xi^2}}{l|x - \xi|}$$

It is found that the required function $p(x)$ may be presented as two parts, whereof one represents the pressure of an absolutely rigid beam, and the second is a correction for finite rigidity. It is demonstrated that for a beam with finite rigidity, as well as for the absolutely-rigid beam, the theoretical value of the reactive forces on the ends of the beam is equal to infinity. Some particular problems are investigated. P. I. Klubin, USSR

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2464. Basler, K., Beam, Locally Reinforced by strip, (in German), *Schweiz. Bauztg.* **74,** 31, 461–464, Aug. 1956.

Paper gives approximate stress analysis of beam, one flange of which is locally reinforced by short strip attached to flange by welds along its edges. It is concluded that short strips can be used effectively. Some rules for design of welds are proposed.
F. J. Plantema, Holland

2465. Chatterjee, P. N., Analysis of two-dimensional footings having variable moments of inertia, *J. Technol.* **1,** 2, 163–174, Dec. 1956.

Title problem is solved analytically and numerically by assuming the ground reaction proportional to the deflection of footing. A power series solution for symmetrical footing is obtained by the method of Frobenius and is shown to be a generalization of a particular solution established by Hetenyi. A numerical solution by successive approximations following Newmark's method is also examined. It is found that the convergence is rapid, the first approximation giving acceptable values for normal design purposes. A practical example of a reinforced-concrete wall footing is included. G. A. Zizicas, USA

2466. Vargo, L. G., Nonlinear minimum-weight design of planar structures, *J. aero. Sci.* **23,** 10, 956–960, Oct. 1956.

A direct method for determining the minimum-weight fully plastic moments of a planar structure (such as a beam, bent on truss) is developed. The method allows use of a general type of nonlinear relation between the fully plastic moments and the areas of the series of cross sections used. Solutions for a two-span beam and a rectangular beam bent under concentrated loads are obtained, and are compared with solutions based on a linear relation between those quantities. The nonlinear relation is found to result in a weight saving of as much as 15% for the beam problem.
B. A. Boley, USA

2467. Berman, M. E., The mechanism of distortion of low-pitch helical springs (in Russian), *Sb. statey Vses. zauch. politekh. in-ta* no. 10, 73–93, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1739.

The theory of strength of materials is applied to the analysis of the stress distribution in the cross section of a spring turn.

The maximum tangent stress is obtained at the point on the periphery nearest to the axis of the spring, and can be represented by the following expression:

$$\tau_{max} = \frac{M1 + \frac{1}{4} r/R}{Wp1 - r/R}$$

The essential contents of this article have already been published by the author in *Dokladi Akad. Nauk SSSR (N.S.)* **82,** 5, 689–691, Feb. 1952 [AMR **6,** Rev. 65].
A. F. Rozhnyatovskii, USSR

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2468. Kostyuk, D. I., A new method of determining the transitional curve radii of a gear tooth profile (in Russian), *Trudi Kharkovsk. aviats. in-ta.* no. 15, 125–132, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1335.

The formation of the transition curve of a gear tooth by means of a rack, and the cutting of the teeth by milling, are analyzed. The Euler-Savary equation of the theory of reciprocally enveloping curves is applied by the author, in accordance with the dimensional relationship between the tool and the blank—i.e., assuming a module of unity—, to the development of the fundamental equation:

$$\rho = \frac{a}{\cos \varphi} + R - \frac{az \cos \varphi}{z \cos^2 \varphi + 2a}$$

where z = number of teeth in the wheel, a distance from the center of the tip transition curve of the cutter tooth to its medium line, R radius of the tip transition curve of the cutter tooth, ρ radius of curvature of the root curve. The angle φ determining the location of the radius of curvature with reference to the common normal to the centroids varies between 0° and 70°. The case of forming the teeth by milling is investigated similarly.

Curves are given of the change in curvature of the root transition of gear wheels depending on the number of teeth, for a given value of the curvature of the root transition, assumed as the optimum in determining the coefficient of (stress) concentration.
Courtesy of Referativnyi Zhurnal D. F. Blokh, USSR
Translation, courtesy Ministry of Supply, England

2469. Klein, B., Comment on the reliability of the strength of stiffened cylinders in bending and/or compression, *J. aero. Sci.* **23,** 12, 1126–1127 (Readers' Forum), Dec. 1956.

2470. Savin, G. M., Dynamic forces in a hoisting rope on raising a load from an immovable foundation (in Russian), *Dopovidi Akad. Nauk Ukrain. RSR* no. 2, 140–147, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1652.

The rope is regarded as an elastically tough filament. The dynamic equation is derived for a mine hoisting rope, assuming the damping to be proportional to the velocity. Two stages of the process of hoisting the load are examined: the lifting of the load off a stationary foundation, and its further raising. The problem of determining the maximum stresses in the rope during hoisting is reduced to finding the first maximum or peak stress at the beginning of the second stage of hoisting, which is attained within a very short time interval; according to author's calculations, the error should not exceed 1%. The author is of the opinion that, in determining the dynamic forces in the rope, the change in length of the latter and its incomplete elasticity may be neglected.
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Plates, Disks, Shells, Membranes

(See also Revs. 2401, 2427, 2428, 2429, 2439, 2454, 2457, 2493, 2494, 2495, 2515, 2519, 2542)

Book—2471. Goldenveizer, A. L., and Gostekhizdat, M., Theory of elastic thin envelopes, 1953; 544 pp., *Ref. Zh. Mekh.*, 1956, Rev. no. 3080.

In the first part of the book a short summary is given of the theory of surfaces, namely static and geometric relationships, relationships of elasticity and general theorems, the basic equations of the linear theory of envelopes. The basic relationships of the theory of envelopes are derived with the aid of vector analysis for an arbitrary nonorthogonal system of Gauss coordinates of the mean surface. Relationships of elasticity are plotted, starting from the hypothesis of the retention of a linear element; the analysis is performed of various variants and the conditions are determined which they should satisfy so that the general equations of the theory of elasticity are applicable to the theory of envelopes. A comparatively simple variant of the elasticity relationships which satisfies these conditions is given. For the first time in a monograph the following problems are dealt with: (1) determination of the displacements according to the given deformation components; (2) the analogy between geometric and static relationships which enables the assumption of the duality of homogeneous relationships of the theory of envelopes to be formulated; (3) analysis of the methods of solving problems of the theory of envelopes in forces—moments and displacements, from which it follows that the inaccuracy of the relationships of elasticity will first of all be brought to light in the calculation of long envelopes.

In the second part, the non-moment theory of envelopes is examined. It is stressed that calculation of the non-moment envelope may be considered finished when it has been demonstrated that the displacements can be determined. Accordingly, calculation of the non-moment envelope in principle is divided into three problems, a static, geometric, and mixed one. The problem is examined of variation of the boundary conditions in transition from a moment envelope to a non-moment one. For conjoint geometric and static problems of the non-moment theory, conditions are determined when calculation of the non-moment envelope is formally possible; in the case of one smooth boundary, an analysis is made of the number of solutions of the static and geometric problems. A detailed calculation is given of the non-moment spherical envelope with the aid of the analytical function of a complex variable.

In the third part, a calculation is given of circular cylindrical envelopes by the method of expanding the solutions into trigonometric series. The properties of the roots of the characteristic equation are elucidated dependent upon the parameter (index of the resolution term), and the simplified characteristic equations are determined from which the approximate values of the roots may be found by a more or less simple method; simplified calculation relationships are given which lead to the earlier determined simplified characteristic equations. The asymptotic error is determined of the approximate relationships, or, in the case of a prescribed accuracy, the region of applicability of the various approximation methods of calculating specific stress states. Besides the solution of this basic problem it is shown in passing that, in the solution of the cylindrical envelopes with the aid of a potential function, certain solutions may be lost which correspond to the zero roots of the characteristic equation.

In the fourth part, a complex analysis is given of the stressed state of an arbitrary envelope. First of all the asymptotic properties of the integrals of a homogeneous linear differential equation in the particular derivatives

$$L(\Phi) + h_*^2 N(\Phi) = 0 \qquad [*]$$

are elucidated, which are shown when the parameter h_* relative to the thickness of the envelope tends to zero. In [*] $N(\Phi)$ is the differential expression of the eighth order of the elliptic type, $L(\Phi)$ is of the fourth order, however, of the elliptic, completely hyperbolic or degenerate parabolic type. The solution [*] is sought in the form

$$\Phi = \varphi(\alpha, \beta; k)e^{kf(\alpha, \beta)} \qquad (k = h_*^{-t}) \qquad [**]$$

where t is the given positive constant, the so-called index of variability of the required integral. The function of intensity φ is assumed represented by the asymptotic series

$$\varphi(\alpha, \beta; k) = \varphi_0(\alpha, \beta) + \frac{1}{k}\varphi_1(\alpha, \beta) + \frac{1}{k^2}\varphi_2(\alpha, \beta) + \ldots$$

The method of solving the problem consists in the successive determination of the functions f, φ_0, $\varphi_1, \ldots$. The peculiarities of the problems of the theory of envelopes are considered: (1) $L(\Phi)$ and $N(\Phi)$ have multiple characteristics, (2) the supporting contour may coincide on a certain section with the characteristic $L(\Phi)$ or touch it at specific points. The basic properties of the integrals of equation [*] are explained.

Further, the asymptotic integration of the equations of the theory of envelopes in the displacement u, v, w is adduced, giving them in the form

$$u = k^{\lambda}U(\alpha, \beta; k)e^{kf(\alpha, \beta)}$$
$$v = k^{\mu}V(\alpha, \beta; k)e^{kf(\alpha, \beta)}$$
$$w = k^{\nu}W(\alpha, \beta; k)e^{kf(\alpha, \beta)}$$

where $U(\alpha, \beta; k)$, $V(\alpha, \beta; k)$, $W(\alpha, \beta; k)$ are assumed to be the introduced asymptotic series

$$U(\alpha, \beta; k) = u_0(\alpha, \beta) + \frac{1}{k}u_1(\alpha, \beta) + \text{, and so on.}$$

Integration of a homogeneous system of equations of the linear theory of envelopes in displacements is reduced to the successive determination of function f; u_0, v_0, $w_0, \ldots$

By this means, (1) the asymptotic error of equations of the non-moment theory is determined, which is found to be identical for envelopes of positive and negative curvature; (2) it is shown that at $t < 0.5$ the homogeneous equations of the theory of envelopes have so-called basic integrals, at which $f(\alpha, \beta)$ is constant on a specific family of asymptotic lines of the mean surface; along this asymptotic line the corresponding basic integral is determined with an accuracy up to two constants (on the twofold asymptotic line of the surface of zero curvature with an accuracy up to four constants). It is shown that the number of integrals of the type of the boundary effect is equal to $4 + 2s$, where s is the multiple quality of the asymptotic line on the supporting contour ($s = 0, 1, 2$).

Based on the results of integration, the approximate solving equations are constructed and numerical relationships for determining the elementary stressed states, into which enter: the basic stressed state, the stressed state with a large variability exponent ($t > 0.5$), simple boundary effect, generalized boundary effects along the asymptotic supporting contour—non-degenerating (at $t > 0$) and degenerating (at $t < 0$). The asymptotic errors of the introduced approximate methods are determined for calculation of the elementary stressed states, explaining the regions where these various methods are applied. This is the main theme of the book.

In the fifth part, the approximate methods for calculating the elementary stressed states of envelopes are set out, giving most attention to the practical aspect of the matter. In the chapter on the application of resolutions according to orthogonal functions to calculation of the envelopes it is shown that the functions and their derivatives of the orthogonal systems, with which one has to work when calculating envelopes of zero curvature, are homogeneous according to the character of the variability.

Five sufficient conditions of the applicability of the non-moment theory are formulated. It is pointed out that in the sense of the applicability of the non-moment theory one must compare the envelopes of non-positive curvature with the envelopes of positive curvature, and views relating to this assumption are adduced.

The simple boundary effect and calculation of the envelopes according to the non-moment theory are considered, taking the boundary effects into consideration. The following portion refers to cases when the conditions of applicability of the non-moment

theory are disturbed: calculation of the stressed state with a large component of variability, calculation of the envelopes with non-rigid boundary reinforcements, calculation of open cylindrical and conical envelopes, where the contour line coincides in a certain section (or sections) with an asymptotic line of the mean surface. For each elementary stressed state its basic properties are given in extended form. The exposition of the theory in the fifth chapter is accompanied by simple examples which are, however, important in principle. In a number of cases an estimate of the accuracy is given in determining the full stressed state according to approximation methods.

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2472. Yoshimura, Y., and Nitsawa, J., Lower buckling stress of circular cylindrical shells subjected to torsion, *J. aero. Sci.* **24,** 3, 211–216, Mar. 1957.

An approximate deflected shape based on experimental observations is assumed and potential energy is minimized for finite deformations. Assumed shape does not represent completely realistic end conditions. Different results are found according to whether uniform circumferential displacements are prescribed at ends or whether nonuniform displacements are permitted. For the second case, snap-through buckling is found possible and computed minimum buckling load is found which lies between ordinary linear buckling and experimental results. For the first case it is concluded that snap-through buckling is not possible.

G. W. Housner, USA

2473. Naghdi, P. M., On the theory of thin elastic shells, *Quart. appl. Math.* **14,** 4, 369–380, Jan. 1957.

Paper gives an extension of previous work by E. Reissner on thin elastic shells of revolution [AMR **5,** Rev. 3357] to shells of general shape. Using vector notation and taking lines of curvature as coordinate lines in the middle surface, author gives expressions for strain components as functions of the displacement vector. It is assumed that displacements parallel to the middle surface are determined by the slope changes of the normal to the surface alone, but the displacement along the normal is supposed to be a quadratic function of the distance from the middle surface. Then the relations between stress components and the resulting forces and couples are assumed, which satisfy the moment equilibrium condition about the normal identically. Stress equilibrium conditions, boundary conditions, and stress-strain relations are then derived from E. Reissner's variational theorem [AMR **4,** Rev.2381], and these are compared with Love's approximations. Finally, it is shown how, in the usual dynamic equations for shell vibrations, the rotatory inertia can be taken into account.

Paper is intended as a higher approximation to the usual theory of thin shells and permits interesting comparisons. It would be of interest, however, to extend these to numerical results for some extreme cases of simple shell forms, because, in reviewer's opinion, there are serious difficulties in choosing the form of approximations by purely theoretical reasoning.

A. Kuhelj, Yugoslavia

2474. Bodner, S. R., General instability of a ring-stiffened, circular cylindrical shell under hydrostatic pressure, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-30, 9 pp.

The general instability of the shell structure under consideration (buckling of both rings and shell) may be investigated by three different methods: (1) An analysis of an equivalent orthotropic shell; (2) an energy analysis; or (3) a solution of the differential equations of the composite structure. Paper is concerned with the first approach, and the equations for the orthotropic shell are obtained from the strain energy of the shell by variational methods. The accuracy of these equations is approximately the same as that of Donnell's equations for the isotropic shell.

The orthotropic equations are solved for the case of a simply supported shell under hydrostatic pressure, and the results obtained are compared with the theory due to W. Flügge and also with the results obtained by S. Kendrick. In an appendix, an energy-method solution to the problem is outlined which is very suitable for a Rayleigh-Ritz approximation.

Reviewer feels that the comparison of results from different approaches should have been followed by comparison with experimental results. (The data for the numerical examples worked out are taken from models to be tested.) Reviewer also finds a clear-cut conclusion to be lacking. L. N. Persen, Norway

2475. Becker, H., Donnell's equation for thin shells, *J. aero. Sci.* **24,** 1, 79–80 (Readers' Forum), Jan. 1957.

2476. Herzog, M., Analysis of arbitrary dome-shaped dams by shell theory (in German), *Bautechnik* **33,** 8, 268–273, Aug. 1956.

General equilibrium equations for variable thickness shell with double curvature are derived; loading by normal pressure (water pressure) and effect of temperature strains are considered. Approximations introduced at this stage are equivalent to those discussed by McNamee [Symposium on Concrete Shell Roof Construction, C.A.C.A. London, 1954]. Two simultaneous fourth-order differential equations with variable coefficients are derived, relating normal deflections and a membrane-stress function to the prescribed loading and temperature distribution. Proposals (in rather general terms) are put forward for the numerical solution of the differential equations; variable coefficients are to be treated as constants. Difficulties arise because boundary conditions for membrane-stress function are unknown except at free top edge; these are partly overcome by introducing empirical relationships obtained from model tests!

Reviewer feels that further work is required to clear up discrepancies such as showing ten boundary conditions for part of the boundary and eleven for the rest, the latter including two fifth-order derivatives of the membrane-stress function that did not figure in previous calculations. G. Sved, Australia

2477. Thurlimann, B., and Johnston, B. G., Analysis and tests of a cylindrical shell roof model, *Trans. Amer. Soc. civ. Engrs.* **120,** 615–649, 1955.

The use of circumferential reinforcing ribs in cylindrical shell structures subjected to radial and longitudinal loading presents a difficult problem in stress analysis. Authors have simplified this problem by the reduction of the rib-reinforced cylindrical section to an equivalent curved T beam. A chart is provided in the paper for determining quickly the effective flange width of the equivalent T beam for any selected configuration. An analysis is made of stresses and stress distribution resulting from longitudinal and sinusoidally varying radial forces, for both complete and partial arc, rib-reinforced cylindrical shell structures.

Boundary conditions including fixed ends, and rotation and displacements of the supporting structure are among those considered. Tests on a steel scale model corroborated the analysis.

There is considerable controversy concerning authors' recommendation of the use of a T beam as opposed to a beam construction in which the flange is in the middle of the web, for some applications with concrete. It would certainly be well worth while to give careful consideration to both sides of this argument. Reviewer feels that this paper gives a thorough presentation of a difficult subject that is a definite contribution. It should prove useful to mechanical as well as civil engineers.

E. G. Allen, USA

2478. Hertel, H., Prestressed shell constructions (in German), Jahrbuch der Wissenschaftlichen Gesellschaft für Luftfahrt, 302–308; Braunschweig, Friedr. Vieweg & Sohn, 1955.

Author investigates briefly, in the introductory paragraphs, the effects of longitudinal stiffeners and circumferential frames (rings) on the general instability of a stiffened circular cylindrical shell under external pressure loading. It is shown that longitudinal stiffeners have very little reenforcing effect; hence, they are practically useless for this type of loading.

Author compares, for conventionally stiffened cylinders, the buckling strength of the sheet between the rings and the local crippling strength of the rings. The latter is usually much higher. By prestressing the skin in the circumferential direction which causes additional compression in the rings, it is possible to make both critical stresses equal (optimum design). Charts are given to show the influence of some of the important structural design parameters.

In the second part of the paper, practical methods of prestressing of the skin are discussed. Author recommends particularly the method of spiral armouring. A thin-walled profile representing the rings is wrapped spirally around a cylindrical core of which the diameter should be 0.80–0.90 of the shell diameter. After inserting the core with the spiral wrapping in the cylinder, the core is removed and the spiral ring presses against the skin, now causing the desired prestressing.

F. M. Mueller, USA

2479. Flindt, C. B., Theory of restrained corrugated diaphragms, *Engineer, Lond.* **202,** 5246, 193–195, Aug. 1956.

Author uses the mathematical linear theory for restrained corrugated diaphragms, developed by J. A. Haringx in 1950 [AMR **4,** Rev. 2861]. Examples are given and tests reported which show an excellent agreement between test and theory in the investigated cases.

G. Supino, Italy

2480. Yuan, S. W., and Ting, L., On radial deflections of a cylinder subjected to equal and opposite concentrated radial loads, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-64, 5 pp.

The title problem was solved by S. W. Yuan [see "Thin cylindrical shells subjected to concentrated loads" *Quart. appl. Math.* **4,** 1, 13–26, 1946] by solving Donnell's differential equation of eighth order. In the present paper, Flügge's equations have been used to solve the same problem. The same Fourier integral method is introduced to obtain the solution of an infinitely long cylinder. Method of images has been further used to obtain the solution for cylinder of finite length with simply supported ends.

Radial deflections computed in this paper are compared with corresponding results obtained previously [op. cit.] from Donnell's equations. It is remarked that the difference in maximum deflection for an infinitely long cylinder in the two cases is about 25%, whereas for a cylinder of finite length the difference is about 6%.

D. N. Mitra, India

2481. Buchwald, T., and Tiffen, R., Boundary-value problems of simply-supported elastic plates, *Quart. J. Mech. appl. Math.* **9,** 4, 489–498, Dec. 1956.

Complex variable methods are used to obtain solutions of simply supported plates in the form of half plane and infinite strips. A uniqueness theorem is proved and it is shown that the conditions required at infinity depend on the boundary conditions.

B. R. Seth, India

2482. Kaliski, S., and Nowacki, W., Some problems of structural analysis of plates with mixed boundary conditions, *Arch. Mech. stos.* **8,** 4, 413–448, 1956.

Authors discuss the problem of deflection of isotropic plates with relatively general assumptions concerning the support along the periphery and inside the region of the plate. Discontinuous elastic or rigid supports or clamps, and the presence of elastic foundations in certain regions of the plate are considered, assuming linear characteristics of these supports, clamps, and foundations. The general case is reduced to a system of Fredholm integral equations of the first or second kind, depending on whether rigid or elastic clamping is considered. The equations obtained express conditions of the geometrical compatibility for segments and regions, in which the type of support differs from the basic system (usually a simply supported plate).

Representation of the sought values in the form of orthogonal series enables reducing the systems of integral equations of the first kind obtained to infinite systems of algebraic equations. These enable, in certain cases, the solution in an explicit form. Authors solve systems of equations of the second kind by using the iteration method, the error being discussed and appraised. The theory is illustrated by a series of examples concerning rectangular plates one edge of which is partially simply supported, partially clamped or free; systems of rectangular plates in contact along edges; plates with slits, linear and surface supports, etc. Finally, authors discuss the physical interpretation of the general relation between the Fredholm equations of the first and second kind, which can be reduced to the passage to a certain limit.

M. Sokolowski, Poland

2483. Horvay, G., and Born, J. S., Some mixed boundary-value problems of the semi-infinite strip, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-54, 8 pp.

Rigorous solutions are given for the semi-infinite elastic strip, traction-free along the long edges, when the short edge is subjected (a) to a quadratic shear displacement, zero normal stress, (b) to a cubic normal displacement, zero shear stress. The solution is found by identification of the semi-infinite strip problem with the problem of an infinite strip with certain normal and shear traction distributions along the edges for $x < 0$ and with traction-free edges for $x > 0$. The known solution of the latter problem gives the desired stress and displacement distributions at $x = 0$. It is shown how, for case (a), the stress function for $x \geqslant 0$ may be converted into a biharmonic eigenfunction expansion by means of the residue theorem. The existence of a shear stress singularity in case (a) at the corner $(x, y) = (0, \pm 1)$ is demonstrated.

The approximate variational method, based upon the use of orthogonal, self-equilibrating edge polynomials in the mixed boundary-value problems of the semi-infinite strip [AMR **6,** Rev. 3018], is extended.

Figures illustrate the resulting stress distributions in cases (a) and (b). In its very concise form paper is difficult to read, and for some fundamental statements it refers to a paper still in press.

J. F. Besseling, Holland

2484. Wegner, U., Calculation of partially cantilevered rectangular plates with given boundary bending moment (in German), *ZAMM* **36,** 9/10, 340–355, Sept./ Oct. 1956.

Paper begins with an examination of an incomplete, co-orthogonal complex system of biharmonic functions. For many partially built-in plates the coefficients of this system are given in a closed form, similar to that given by Fourier.

Method is applied to the following problems: (a) rectangular plate built-in at two opposite edges, hinged at the two other edges and submitted at these edges to bending moments equal in size; (b) the same plate submitted at the hinged edges to bending moments different in size; (c) rectangular plate built-in at three edges, hinged at the fourth edge and submitted at this edge to bending moment; (d) the same plate heated at the hinged edge. The temperature is expressed by a twice continuously differentiable function continuously decreasing to zero at the ends of the edges.

All moments are expressed by sectionally continuous, continuously differentiable functions which are symmetrical with respect to the centers of the edges at which the moments are applied. No numerical values are given.

S. T. A. Odman, Sweden

2485. Duncan, J. P., Rational design of stayed tube-plates. Parts I, II, *Engineering* **182**, 4727, 459–463, Oct. 1956; **182**, 4729, 525–529, Oct. 1956.

Method described rests upon the theories of eccentrically loaded plates developed by Föppl and Michell and upon theories of tube-plate rigidity by author. The procedure, which employs the concept of a "group influence coefficient," has been presented in simplified form for design purpose.

From author's summary by F. I. Niordson, Sweden

2486. Sokolowski, M., The stability of an orthotropic infinitely long plate with ribs, *Arch. Mech. stos.* **8**, 4, 507–538, 1956.

An infinitely long orthotropic plate, simply supported at the edges and reinforced with asymmetrical ribs, is subjected to a vertical load and to uniformly distributed compressive loads. The ribs are subjected to a uniform bending load and concentrated compressive forces. The solution is obtained by using simple Fourier series.

The state of stress and strain in the plate due to the vertical and horizontal loads, acting in its plane, and the state of stress and strain in the beam constituting a rib are considered separately. The forces between the plate and the rib are assumed in the form of Fourier series with unknown coefficients, thus obtaining the deformations and the displacements of the girder and the plate. For the determination of the unknown expansion coefficients, four conditions of continuity of deformation of the rib and the plate (rotation angle, horizontal and vertical displacements, and horizontal deformation parallel to the rib) are established. Various cases of stability and buckling of an infinitely long plate with symmetrical ribs and without ribs, as well as bending and buckling conditions of an infinitely long plate with asymmetrical ribs, are discussed in detail.

Paper contains numerous diagrams for various forms of plate buckling.

J. Mossakowski, Poland

2487. Mossakowski, J., The Michell problem for anisotropic semi-infinite plates (in Polish), *Arch. Mech. stos.* **8**, 4, 539–548, 1956.

The problem of a plane state of stress and strain in the case of an elastic semiplane of the general type of anisotropy, subjected to the action of an arbitrary concentrated force, is considered. Author represents the solution of the problem in the form of a sum of twelve terms of the $[A_{sk} z_{sk} (\ln z_{sk} - 1)]$type, where

$$Z_{sk} = X + \mu_s y - \mu_k \eta$$

The coefficients μ are the complex roots of a characteristic equation of the fourth order for an anisotropic plane, and the parameters A_{sk} are obtainable from statical and boundary conditions of the problem. η is the ordinate of the point of action of the concentrated force.

The general and compact form of the solution enables obtaining a series of particular solutions; for instance, in the case of orthotropy and anisotropy, the solution of the problem of a force acting on the edge of an anisotropic plane, etc.

Two numerical examples show essential differences between the stress distribution in isotropic and anisotropic plates, concerning in particular the configuration of compressed and stretched regions.

M. Sokolowski, Poland

2488. Sawczuk, A., Some problems of load-carrying capacities of orthotropic and nonhomogeneous plates, *Arch. Mech. stos.* **8**, 4, 549–563, 1956.

The object of this paper is the axially symmetrical problem of load-carrying capacity of circular orthotropic and nonhomogeneous plates. Author computes the load-carrying capacity of plates on the basis of an analysis of a statically possible stress distribution in the limit state.

A simplified yield condition is assumed, the graphical representation of which, in the system of principal moments, is a hexagon. The directions of orthotropy coincide with those of principal stress.

Establishment of the directions of increase of plastic deformations at the moment of exhausting the load-carrying capacity of the plate enables finding the relation between the principal moments; this relation together with the equilibrium equations determines the limit moments.

Solutions are obtained for plates freely supported or clamped at the periphery, and uniformly loaded over an annular region.

Paper is a generalization of the problem of W. Hopkins and W. Prager to orthotropic or nonhomogeneous plates.

D. Niepostyn, Poland

2489. Szolagowski, F., A semi-infinite plate having a rigid circular inclusion and subjected to tension, *Arch. Mech. stos.* **8**, 4, 695–704, 1956.

A semi-infinite plate subjected to uniform tension p acting parallelly to the rectilinear edge and having a rigid circular inclusion of radius r_0, the center of which is located at the distance b from the edge, is considered. By mapping conformally the region under consideration into a circular ring, the problem of determination of stress distribution reduces to Dirichlet problem for this ring. Stresses and strains in the semi-infinite plate without rigid inclusion are assumed to act at the edge with the opposite sign. By substituting these values into Schwarz formula for a circle, the problem reduces to the determination of two integrals along the periphery of the circle. For the determination of these integrals two terms of the trigonometrical series representing the Jacobian function $\theta_4(u)$ appearing under the integration symbol are taken into consideration. By adding the solution thus obtained to that for the plate without rigid inclusion, final result is obtained. This approximate solution enables a sufficiently exact determination of the maximum stresses appearing in the plate at the boundary of the rigid inclusion, for a certain class of parameters r_0 and b, most common in practical problems.

For a steel plate the maximum stress for $b = 4r_0$ is shown to be equal to $2p$ approximately.

J. Mossakowski, Poland

2490. Umanskii, E. S., Stressed state of a disk loaded with radial forces of arbitrary intensity distributed over individual sectors (in Russian), *Bull. Kiev Polytechnical Institute* **16**, 288–294, 1954 (1955); *Ref. Zh. Mekh.* 1956, Rev. no. 3077.

An examination is made in connection with the calculation of rotating disks strengthened by radial ribs of the stressed state of a disk of constant thickness loaded in the central plane by radial forces distributed over the sectors. Within the limits of each sector the intensity of forces varies uniformly over the circumference, and along the radius according to the law

$$q(r) = \sum_{m=1,2} q_m r^m \quad (q_m = \text{const})$$

In order to solve the problem, the intensity of the given load is varied continuously by means of expansion into Fourier series

$$R = \frac{nq(r)\epsilon}{\pi} + \frac{2nq(r)}{\pi} \sum_{k=1}^{\infty} \frac{\sin kn\epsilon}{kn} \cos kn\theta$$

(n is the number of sectors, 2ϵ is the central angle comprising one sector). Then expressions are selected for the stresses σ_r, σ_θ, $\tau_{r\theta}$, containing the stresses function φ and satisfying the equations

of equilibrium of the two-dimensional problem, and a homogeneous equation is formed relative to φ

$$\Delta\Delta\varphi = -\frac{1+\mu}{b}\psi(r)\left[\frac{n\epsilon}{\pi} + \frac{2n}{\pi}\sum_{k=1}^{\infty}\frac{\sin kn\,\epsilon}{kn}X\right.$$

$$\left. X\cos kn\,\theta\right] + \Delta\left\{\eta(r)\left[\frac{n\epsilon}{\pi b} + \frac{2n}{\pi b}\sum_{k=1}^{\infty}\frac{\sin kn\,\epsilon}{kn}\cos kn\,\theta\right]\right\}$$

where

$$\Delta = \frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{1}{r^2}\frac{\partial^2}{\partial\theta^2}$$

$$\psi(r) = \frac{dq(r)}{dr} + \frac{1}{r}q(r), \quad \eta(r) = \frac{1}{r}\int_0^r r\,q(r)dr$$

The solution is found in the form

$$\varphi = F(r) + \sum_{k=1}^{\infty} f(r)\cos kn\theta$$

using the known solutions of the biharmonic equation $\Delta\Delta\varphi = 0$.

Equations are given for stresses and displacements enabling the calculation of a full disk, and of a disk with a central orifice, to be made. It is pointed out that, with the aid of a limit transition, solutions are obtained for a disk loaded by forces distributed along the radius. No numerical examples are given in the paper, nor is there any indication as to what number of terms at various values of ϵ and n should be taken in the solutions in order to obtain a result with an accuracy sufficient for practical use.

Courtesy Referativnyi Zhurnal A. D. Kovalenko, USSR
Translation, courtesy Ministry of Supply, England

Buckling Problems

(See also Revs. 2380, 2469, 2472)

2491. Berman, M. E., On the longitudinal stability of beams (in Russian), V. sb. Raschety na prochnost', zhestkost', ustoychivost' i kolebanya, Moscow, Mashgiz, 216–222, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1694.

The accepted derivation of the Euler force in the problem of the longitudinal flexure of a compressed beam, which in the opinion of the author is contradictory, is criticised.

Introducing an independent variable u linked with the angle ϕ of rotation of the tangent to the bent axis of the beam and the arc s measured along the axis, by the relationship $du/ds = \cos\frac{1}{2}\phi$, author sets up the "rigorous" equation of the longitudinal curvature of the beam in bending:

$$EI\frac{d^2y}{du^2} + Ny = 0$$

From this, an approximate expression is obtained for the maximum flexure in the ultracritical region

$$f = \frac{2\sqrt{21}}{\pi}\sqrt{1 - \frac{N_{kp}}{N}}$$

resembling the expression given by von Mises.

Courtesy of Referativnyi Zhurnal V. V. Bolotin, USSR
Translation, courtesy Ministry of Supply, England

2492. Guest, J., The compressive buckling of a clamped parallelogram plate with a longitudinal stiffener along the centre-line, *Austr. J. appl. Sci.* **7,** 3, 191–198, Sept. 1956.

Paper extends earlier, separate, publications by author and W. H. Wittrick [AMR **7,** Rev. 461] dealing with the buckling of an unstiffened parallelogram plate. The title plate, clamped on all edges, is compressed parallel to its stiffener. An approximate solution of the variational equation of buckling expressed in oblique coordinates is found by representing the lateral deflections of the plate as a double series of functions having the same form as those used previously by S. Iguchi for the buckling of a clamped rectangular plate. The critical stress is calculated in nondimensional form for a 60° parallelogram having a particular plate/stiffener relation, and the results are compared over a range of side-ratios from 0.6 to 1.4 with Wittrick's solution for the unstiffened plate.

Analysis is presented clearly. Reviewer believes that the second term in the integrand of Eq. [14] should appear as the rth derivative of F_p. L. Maunder, USA

2493. Kimel, W. R., Elastic buckling of a simply supported rectangular sandwich panel subjected to combined edgewise bending and compression, *U. S. Dept. Agric., For. Prod. Lab. Rep.* 1857, 125 pp., Sept. 1956.

Sandwich having unequal isotropic faces and orthotropic core is analyzed by means of Ritz energy method. Analysis leads to infinite determinant for critical load. Solutions presented are for a principal minor of this determinant of order eighteen. Results are presented in curve form for pure compression and pure edgewise bending. H. J. Plass, Jr., USA

2494. Kimel, W. R., Elastic buckling of a simply supported rectangular sandwich panel subjected to combined edgewise bending, compression, and shear, *U. S. Dept. Agric., For. Prod. Lab. Rep.* 1859, 64 pp., Nov. 1956.

Design curves are presented for various combinations of edgewise compression, bending, and shear for sandwich having unequal isotropic faces and orthotropic core. Problem is analyzed by Ritz energy method. Solutions are found using a minor determinant of order forty-eight from the infinite determinant resulting from the analysis. H. J. Plass, Jr., USA

2495. Semonian, J. W., and Peterson, J. P., An analysis of the stability and ultimate compressive strength of short sheet-stringer panels with special reference to the influence of the riveted connection between sheet and stringer, *NACA Rep.* 1255, 18 pp., 1956.

See AMR **9,** Rev. 720.

2496. Masur, E. F., and Cukurs, A., Lateral buckling of plane frameworks, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 1 (*J. Engng. Mech. Div.*), Pap. 1140, 15 pp., Jan. 1957.

Paper considers instabilities of plane trusses in which individual compression members may buckle laterally in a mode involving twisting as well as bending. An extension, using matrix methods, of the "series criterion" of Lundquist [*NACA TN* 617] is used to obtain the stability criterion. In an example, the instability load of a particular truss is shown to be about half that predicted by Euler methods. K. H. Griffin, England

2497. Leiderman, Yu. R., On stability of flat frameworks the material of which is working above the limit of proportionality, when loaded at the nodes (in Russian), *Trudi in-ta sooruzheniy Akad. Nauk UzSSR* no. 4, 51–63, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1635.

It is pointed out that determination of the critical loading values on frames becoming unstable in the nonelastic range is materially complicated by the relationship of the linear elasticity to the critical stress (upper limit of elasticity). A method of successive approximations for the solution of this problem is described, using the technique of displacements. It is indicated that determination of the Karman modulus by the formula

$$T = 4E_1E_2/[E_1^{1/2} + E_2^{1/2}]^2$$

valid for the rectangular cross section, may lead to considerable errors in the case that the cross section differs from the rectangular (particularly in the case of low, flexural values). For rolled sections, the following formula is suggested:

$$T = 2E_1E_2/E_1 + E_2$$

which exactly corresponds to the cross section of the "ideal" double-tee (very thin flanges, web absent).

Courtesy of Referativnyi Zhurnal Ya. G. Panovko, USSR
Translation, courtesy Ministry of Supply, England

2498. Donnell, L. H., Effect of imperfections on buckling of thin cylinders under external pressure, *J. appl. Mech.* **23,** 4, 569–575, Dec. 1956.

Using approximate finite-deflection theory and approximate prebuckling stress-resultants, author derives a relation between the buckling pressure of hydrostatically loaded imperfect cylinders and their change in volume. Only for cylinders with large values of $l/(rt)^{1/2}$ is an elastic postbuckling reduction in resistance found; even then it is only small. Author's theory also predicts, for short cylinders, higher peak elastic buckling pressures than the von Mises theory. However, author does not compare his results with those of von Sanden and Tölke [*Ing.-Arch.* **3,** 24–66, 1933] who, using accurate expressions for the prebuckling stress resultants, also obtained higher buckling pressures for short cylinders than predicted by the von Mises theory.

As with his axial-compression theory, author uses an unevenness factor U to account for initial out-of-roundness, elastic inhomogeneity, etc. By selecting values of U varying from 0.0001 to 0.0003 author then shows his theory can satisfactorily explain a number of tests conducted by the David W. Taylor Model Basin. However, in more than half the tests, author's theory predicts too low a failure pressure. For these cases better correlation between theory and experiment could be obtained by choosing lower values of U. Author, however, prefers to ascribe discrepancy to fixity at the cylinder ends or the fact that the measured failure pressure might have been the maximum sustaining pressure rather than the pressure at which yielding started.

Author does not mention that all the tests used by him to verify his theory can be satisfactorily explained by the simpler small-deflection theory. This latter work [*J. appl. Mech* **23,** 3, 351–358, Sept. 1956], which considers both simply supported and clamped end boundary conditions, can also explain those cases which author, at the present time, does not. Calculations made by reviewer also indicate that, for Models BR-1 and BR-5, present author's theory requires more than three times the initial eccentricity required by the small-deflection theory to effect a correlation between theory and experiment. Reviewer also believes author's figures for the test value for P given in author's *Table 1* for Models BR-1 and BR-5 should be 0.68 instead of 0.81. Instead of verifying author's theory, these two models then failed at pressures lower than predicted by his theory. If these revisions are taken into consideration, author's theory needs much more than three times the initial eccentricity required by the small-deflection theory to explain the behavior of these models.

Despite the foregoing remarks, reviewer found the paper extremely interesting as it is one of the first to show that the elastic postbuckling resistance of hydrostatically loaded cylinders is reduced, if only for large values of $l/(rt)^{1/2}$. Reviewer would, however, like to see more work done on the following:

(1) An adequate definition of imperfections in cylinders. Reviewer appreciates the fact that author's U-factor is a statistical one, including imperfections other than geometrical, but does the author have the data on cylinders to support the values needed to correlate his theory and experiment? Also why, in some cases, does the finite-deflection theory require larger values of initial eccentricity than the small-deflection theory?

(2) The effect of using an initial imperfection shape similar to the assumed elastic deflection under load. With small-deflection theories for cylinders there usually exist other buckling pressures close to the mimimum buckling pressure. Use of an initial imperfection shape similar to that under load is only defensible in these theories at pressures very close to the minimum buckling pressure. Is this also the case with the author's theory? He states that his amplitude of initial deviation should be regarded as taking care of this, as well as other items, but offers no proof to support such an assumption.

(3) The simple criterion used to predict failure by yielding.

(4) The effect on the author's theory of having boundary conditions other than simple supports. The author states that this study is planned. G. D. Galletly, USA

Joints and Joining Methods

(See also Rev. 2533)

2499. Smith, C. R., The fatigue strength of riveted joints, *Aircr. Engng.* **29,** 336, 34–38, Feb. 1957.

In addition to rivet pattern, thickness of splice plates plays an important part; an improvement in fatigue strength of butt joints was obtained by laminating the splice plate so that the first row of rivets engaged only the first of the laminates. The increase in life was attributed to a decrease in bending stress at the first row of rivets, and to a more equal load distribution between the first and second row of rivets.

Static overloading prior to fatigue testing was harmful in some cases and beneficial in others; harmful where the overload was just sufficient to cause relaxing of the residual stress set up by riveting, and beneficial where it was carried high enough to cause redistribution of the load between rivets.

From author's summary by T. J. Dolan, USA

2500. Hazlett, T. H., Coating ingredients' influence on surface tension, arc stability and bead shape, *Welding J.* **36,** 1, 18s–22s, Jan. 1957.

2501. Allen, W. J., and Begeman, M. L., Metal finish seam welding, *Welding J.* **35,** 12, 597–603, Dec. 1956.

2502. Shimanskii, Yu. A., Calculation of electro-welding seams for complex strength (in Russian), Collection of papers on shipbuilding, 75–83, L. Sudpromgiz, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 3222.

A method is given for calculating oblique butt seams, operating under the action of longitudinal forces.

In an oblique seam the normal and tangential stresses are determined according to the generally known formulas for strength of materials. The strength of the seam is determined according to the conventional equation:

$$\sigma_0 = \sqrt{\sigma_1^2 + \tau_1^2 m^2}$$

in which σ_0 is the permissible stress during elongation, σ_1 and τ_1 are the normal and tangential stresses in an inclined surface, m is the coefficient determined as the relationship of the strength limit during elongation to the strength limit in clean shear (with torsion) which the author, on the basis of data given in the relevant literature, suggests assuming equal to 1.2.

Courtesy Referativnyi Zhurnal G. A. Nikolaev, USSR
Translation, courtesy Ministry of Supply, England

Structures

(See also Revs. 2448, 2453, 2459, 2465, 2466, 2476, 2477, 2478, 2482, 2492, 2497, 2526, 2542, 2623, 2706, 2707, 2708, 2709, 2711, 2739, 2741)

Book—2503. Arcangeli, A., Structures in modern architecture [**La struttura nell'architettura moderna**], Vol. 5, STEB Bologna, Sansoni Edizioni Scientifiche, 1956, 370 pp. L.4000.

Book presents all basic principles of structures used in modern architectural design and is being used as textbook in College of Architecture of the Florence University. First chapter deals with structural materials and their mechanical characteristics; chap. 2 with their behavior in completed structures; chap. 3 with their deterioration and protection. The subjects of the following chapters are: Chap. 4, Actual viewpoints about their elastic and plastic resistance, chap. 5, Soil mechanics, foundations, their statics and disturbances (geotechnics); chap. 6, Earthquake-proof structures; chap. 7, Structural skeletons and schemes; chap. 8, Prestressed concrete (precast and hyperstatic structures), prestressed steel structures; chap. 9, Recent developments of structural types (vacuum-concrete, composite structures, floors in reinforced concrete combined with light steel skeleton; chap. 10, Modern techniques in steel structures, welding, prefabricated light structural elements (extruded), particular criteria of their design, two- and three-dimensional structures, torsional effect, elastic instability; chap. 11, Modern techniques of timber structures (various connections with bolts and nails, glue-lamination); chap. 12, Prefabrication and specifications.

Recent progress is thoroughly discussed and illustrated (shell structures, hyperbolic paraboloids, Chelazzi's "Suspenarch" structures, etc.) J. J. Polivka, USA

2504. Saelman, B., Deflection of a circular section cantilever beam with all fibers of root section at elastic limit stress, *J. aero. Sci.* **24,** 3, 234–236 (Readers' Forum), Mar. 1957.

A comparison is made between the maximum deflections of cantilever beams under purely elastic stress with those when sections of maximum moment are behaving plastically.

From author's summary by A. H. Finlay, Canada

2505. Rabinovich, I. M., On a method of solving a system of linear equations in the problems of structural mechanics (in Russian), *Issled. po teorii sooruzheniy* no. 6, 425–434, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1678.

Author returns to the "method of correction" in the solution of systems of linear algebraic equations, which has been used in the mechanics of structures by a number of authors, starting in 1901. The essence of this method may be described as follows:

Required, to find an n-dimensional vector x, constituting the solution of a system of n linear equations.

Let $l_1, l_2, \ldots, l_k = k$ loci; $y_0, y_1, \ldots, y$ represent linear combinations of the remaining $(n\text{-}k)$ loci; y being the solution of the system of the last $(n\text{-}k)$ equations; $l_i + y_i$ $(i = 1,2,\ldots k)$ are the solutions of the corresponding homogeneous system obtained by equating the right-hand parts of the $(n\text{-}k)$ equations to zero. The solution x then has the form

$$x = y_0 + \sum_{i=1}^{k} c_i y_i$$

The coefficient c_i is obtained by substituting x in the first k equations. It is now necessary to solve a total of $(k + 1)$ systems of $(n\text{-}k)$ equations (in order to find the component of the vectors $y_0, \ldots, y_1, \ldots, y_k$), and one system of k equations (to find the numbers of $c_1, c_2, \ldots, c_k$). In his examples, author puts $k = 1$ or 2 (obviously, for large values of k, the method becomes unsuitable).

For trinomial and pentanomial systems of equations, the application of this method has been found impracticable, since the derived systems of $(n\text{-}k)$ equations are found to be triangular.

A mechanical interpretation of the system for the problems discussed is given.

Courtesy of Referativnyi Zhurnal L. A. Lyusternik, USSR
Translation, courtesy Ministry of Supply, England

2506. Baron, F., A circuit analysis of laterally loaded continuous frames, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 1 (*J. Struct. Div.*), Pap. no. 1147, 32 pp., Jan. 1957.

Structures consisting of multiconnected circuits in one plane are considered. Loading is normal to this plane. Structural members may be curved or segmental producing any number of multiconnected circuits. Members may have torsional and bending rigidities. Vierendeel girders, delta wings, highway bridge flooring are only a few examples of such structures. Procedure is introduced as "circuit analysis" and appears to be an extension of shear and torsion analogy. Author includes 21 references of previously introduced techniques. He assumes that torsional and bending stiffnesses or flexibilities of elements are known. Continuity at junction is assumed. Effects of shear deformations and changes in element length are regarded as negligible; however, correction could be made for this effect. Author discusses an extension of column, shear, torsion analogies and describes distribution procedures for determining correction moments and shears. As an advantage, author points out that arithmetical errors are not cumulative and are eventually eliminated.

Author's method allows designer to use his judgment in estimating the structural behavior. Speed of convergence depends on: assumed distribution of moments; shape and number of circuits; relative stiffness of members and circuits; degree of required accuracy. The summation of angle changes and angle changes times distance may be represented by line integrals. Moments, shears, rotations, displacements may be expressed by vector algebra. Geometrical equation—in matrix form. High-speed computers may be employed. Author observes that distribution procedures of circuit analysis are complementary to moment-distribution techniques. V. A. Valey, USA

2507. Makowski, Z. S., and Gogate, M. N., Stress analysis of three-pinned arch-ribbed domes, *Proc. Instn. civ. Engrs.* **5,** 3, 824–844, Dec. 1956.

Domes consisting of a series of identical three-hinged, semicircular arches of constant moment of inertia, and subjected to a horizontal or vertical load in the plane of the ribs, are considered. Since the deflection of the crown joint is identical for all ribs, it is rather simple to obtain expressions for vertical and horizontal reactions of the loaded rib and the unloaded ribs (all of the latter have identical values).

Analytical results for a dome consisting of four arches are compared to values obtained by means of a small model. For the defined structure, the analytical procedure is theoretically correct, and a model test could only be expected to indicate important errors in mathematical manipulation or arithmetical computation. Some differences between the analytical and experimental results are explained by the authors on the basis that this was not a perfectly true model of the defined structure.

J. Michalos, USA

2508. de Stein, J. L., and McCutcheon, J. O., Lateral rigidity of steel building frames, *Engng. J., Montreal* **39,** 10, 1343–1349, Oct. 1956.

Paper approaches the problem of required stiffness by means of rational analysis and on the basis of probable movements as related to building materials. The question of required rigidity for many buildings is at present rather empirical and tends to be left

to judgment. The problem is topical, with the recent incorporation of new design methods in both British and Canadian design specifications and with the extensive use of continuous fenestration and panel-wall construction. From authors' summary

2509. Braun, O., A new method for the calculation of statically indeterminate framed structures (in German), *Stahlbau* **25,** 10, 236-245, Oct. 1956.

Author presents a new method of calculation applicable to the analysis of statically indeterminate framed structures. Different systems of stresses are superposed on the stress state of the principal system, whereby the conditions of deformation are satisfied. The chosen system of stresses is made to act on suitably selected parts of the structure. Such systems of stresses are applied as will produce the actual stress state of structure, when superposed on the stress state of the principal system. If the structure is n-times indeterminate, n systems of stresses, linearly independent of one another, are required to satisfy the conditions of deformation. The proportion of their application is determined by work equations. The latter are similar to the conventional elasticity equations as to their form. The difference is only that unknowns of the equations are not forces but numerical ratios, and the coefficients of unknowns are not deformations but work values.

In connection with examples the paper deals in detail with the expedient assumption of systems of stresses, demonstrating that the latter may be selected in every respect so that the laws apparent in the buildup of the structure manifest themselves in the structure of the elasticity equations as well; thereby, the possibility of different simplifications offers itself.

The presented method is of significance from the theoretical point of view too, but its importance lies principally in the fact that it makes possible the simplification of calculations in some cases. The new method deserves serious consideration by practical structural engineers. P. Csonka, Hungary

2510. Ifrim, M., Analysis of frame structures by successive approximation (in Rumanian), *Indust. constr. Mater. constr.* **7,** 3, 163-169, Mar. 1956.

Discussion and application of methods published by A. Slavin, K. Sattler, Hardy Cross and others. Examples of multiple-span frames with and without sidesway. J. J. Polivka, USA

2511. Kirste, L., Simplified calculation of the stability of multistory frames, *Publ. int. Assn. Bridge struct. Engng.* **16,** 295-300, 1956.

Author presents a method of determining the loads, or the load factor in case of given loads, to cause instability of a simple, symmetrical multistory frame consisting of two columns connected to each other by horizontal girders not necessarily identical. The loads are vertical, identical for both columns, and act at joints.

The moment to cause unit rotation of one end of a section of column (called "transmitted stiffness") is expressed in terms of the EI/L of the section itself, the combined stiffness of all members connected to the other end of the section, and the longitudinal force in the section. The load factor by which the actual loads must be multiplied to arrive at instability is found by trial and error, using a stepwise calculation in which the stiffnesses of successive column segments are computed.

M. P. White, USA

2512. Chesson, E., and Munse, W. H., Behavior of riveted connections in truss-type members, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 1 (*J. Struct. Div.*), Pap. no. 1150, 61 pp., Jan. 1957.

The tests reported herein were performed to provide information on the general behavior of large truss-type riveted steel connections. The variables of the test program included specimen configuration, method of hole preparation, and size of rivets. A study is made of the comparative behavior of the specimens, the distribution of load to the gusset plates, the strains in the lacing bars, the effect of hole preparation, and the predicted and computed efficiencies of the connections.

From authors' summary

2513. Beck, H., A new method of analysis for rigid jointed plane truss as explained in Vierendeel girder example (in German), *Bauingenieur* **31,** 12, 436-443, Dec. 1956.

An original method is presented to solve particular forms of highly redundant structures—multiple superposed Vierendeel girders—supporting vertical and horizontal loads. Author substitutes for the original discontinuous structure a continuous one, without disturbing seriously the characteristic properties of the original frame; several redundants are united in one single unknown function, while the corresponding sets of simultaneous equations are replaced by a differential equation. The regularity of the particular frames studied and the fact that the selected redundants (horizontal shears in the different vertical posts) are of the same type determine favorable conditions to establish, by a suitable function, a correspondence between redundant values and respective positions. The greater the number of redundants involved, the better are the computational results; the accuracy of the method increases with increasing complexity of the structure and corresponding difficulty of solution by usual processes.

A clear and detailed explanation is made of the general analytical solution of the so-called "fundamental case" of Vierendeel truss; ready formulas are developed for particular supporting and loading conditions. A numerical example is explained in detail and results, obtained by author's method applied in nine different types of Vierendeel trusses, are compared with values computed by usual processes, including the so-called "exact method." Very good agreement is shown by post shear values obtained and, what is most remarkable, an unexpected good coincidence of results appears even in cases of a small number of vertical posts. A numerical application of the method to a more complex structure (frontal frame of a multi-storied building, subjected to horizontal and vertical forces) will be explained in a future paper.

I. Wolff, Brazil

2514. Dorn, W. S., and Greenberg, H. J., Safety factors and superposition in the elastic and plastic analysis of frames, Proc. second Midwestern Conf. solid Mech., Purdue Univ., Sept. 1955. 135-149.

Authors prove several theorems concerning the elastic and plastic safety factors of plane frames. The elastic safety factor is defined as the largest number by which a given set of loads can be multiplied without causing the yield stress in any member to be exceeded; to define plastic safety factor, replace "yield stress" by "fully plastic moment" in the above. Certain theorems of superposition are shown to exist for both factors, and various relations between the two factors are proved. Apart from their intrinsic interest, authors' proofs illustrate again the power of the principle of virtual displacements as a tool in structural analysis. P. Symonds, USA

2515. Rudiger, D., Exact theory of folded plate structures with constant curvature (in German), *Öst. Ing.-Arch.* **11,** 1, 5-20, 1957.

Problem solved deals with a platform structure of the shape of a circular ring sector and consisting of concentric ring-sector plate panels supported and connected to each other by circular beams. In the presence of lateral loading, the statically indeterminate interreactions developed between the plate panels and beams are determined by the compatibility conditions of the deformations. Bending and stretching of the plate are considered separately by using classical theories. For the circular beams, the results of F. K. G. Odqvist [AMR **8,** Rev. 1321] are employed. When circular

beams are replaced by cylindrical shell elements, use of N. J. Hoff's work [AMR **8**, Rev. 2321] is recommended.

Solution is actually for the case symmetrical about the central radial line of the structure. Although author claims it to be exact, no particular attention is paid to conditions at the two radial boundary lines. Y.-Y. Yu, USA

2516. Stefanescu, I., Gheorghita, S., and Georgescu, D., Use of large wall blocks for apartment and other buildings (in Rumanian), *Indust. constr. Mater. constr.* **7**, 1, 29–44, Jan. 1956.

Large concrete blocks and wall panels for bearing walls and partitions of various size (up to approximately 100 sq ft) and thickness (from about 4 to 12 in.), some of them hollow, and other types (e.g. sandwiched), are thoroughly described and their manufacture and assembly reported, including special units for corners, intersecting walls, windows and doors. References are made to Russian methods. J. J. Polivka, USA

2517. Kovacs, O., Distribution of loadings on crane bridges between planes of head girder and auxiliary girders (in Hungarian), *Gép* **7**, 9, 333–338, Sept. 1955.

Truss bridges with head girders and auxiliary girders are statically multiply indeterminate space structures. The methods of calculation generally used reduce the construction usually to statically determinate girders. This leads to overdimensioning and wrong mass distribution. In this case, the reverse of loading capacity is disproportionate in the different elements; some of them may be overloaded.

Author tries to approximate the real loading of the elements by taking account of the fact that the bridge structure is also submitted to torsion due to the loading. The center of torsion is determined by the assumption of the equal deflection of the auxiliary and head girders after transposition of loading forces. Once given the center, the deflecting forces loading the two vertical trusses and the moment of torsion acting on the bridge can be determined.

The loadings in each plane caused by the torsional moment are determined also by conditions of deformation, and the loadings caused by deflection and torsion are superposed. The conditions of deformation used for the determination of torsional loadings are not verified correctly, but author refers to a series of measurements to be published in a following article which—according to his opinion— will confirm his theory.

Some principles of construction drawn from the theory are given at the end of the paper. The merit of the paper lays in pointing out a more approximate method of calculating the real loadings of crane bridges with auxiliary girders. Nevertheless, the theory of determination of torsional loadings requires further detailed investigations. G. Pattantyus, Hungary

2518. Uppal, H. L., and Singh, G., Dissipation of energy at high head hydraulic structures by double jet dissipator (French and English), *Houille blanche* **11**, 1, 8–22, Jan.-Feb. 1956.

Energy dissipation below hydraulic structures such as spillways, falls, weirs, etc., is generally brought about by the formation of an hydraulic jump. This requires a certain minimum depth of water at the downstream end. This may not be obtainable in all cases. A new type of dissipator known as Double Jet Dissipator has been developed.

It is a corrugated deflector with the troughs extended further downstream of the crests to form a second series of deflectors. It is constructed at a suitable point on the slope of a spillway or a fall. Flow taking place down the glacis is split up into a number of jets which interact with each other in the air and dissipate energy. An important feature of the Double Jet Dissipator is that it has no part projecting into the high velocity jet nor does it involve any sudden change in the direction of flow.

Different aspects of the energy dissipator such as the spacing of the crests and troughs, position and angle of the second deflector, flare of the extensions, etc., were investigated on the existing hydraulic models of Bhakra Dam over-flow spillway. A suitable design has been evolved. The experiments show this to be very efficient. The depth of scour in some cases has been reduced by over 90%. From authors' summary

2519. Cooper, W. E., The significance of the tensile test to pressure vessel design, *Welding J.* **36**, 1, 49s–56s, Jan. 1957.

Paper discusses the relationship between the tensile properties of materials and behavior as pressure vessels. The material is assumed to be ductile so that local stress concentrations can be neglected. Author concludes that the maximum pressure which the vessel can withstand depends upon the yield and strain-hardening characteristics of the material as well as on the ultimate tensile strength. Some qualitative remarks are made concerning the relation between brittle and ductile materials.

P. G. Hodge, Jr., USA

2520. Hveem, F. N., and Tremper, B., Some factors influencing shrinkage of concrete pavements, *J. Amer. Concr. Inst.* **28**, 8, 781–789, Feb. 1957.

2521. Rosca, V., and Dumitrescu, D. V., New methods and treatment of vacuum concrete (in Rumanian), *Indust. constr. Mater. constr.* **7**, 2, 69–78, Feb. 1956.

Properties and advantages of vacuum concrete are thoroughly described and recent tests and improvements in treatment, made by A. Coroeanu, E. Barbu and C. Ionescue, are presented. References are also made to publications by S. S. Cordon, Chersberg, R. L'Hermite, Leviant and V. Nicolau.

J. J. Polivka, USA

2522. Morice, P. B., and Lewis, H. E., Prestressed continuous beams and frames, *Proc. Amer. Soc. civ. Engrs.* **82**, ST 5 (*J. Struct. Div.*), Pap. no. 1055, 29 pp., Sept. 1956.

This work refers to prestressed hyperstatic structures utilizing "concordant" tendons, i.e., tendons which have a profile such as not to produce any parasitic reactions which would modify the curve of pressures ("Zwangungsfrei Vospannung"). Authors describe methods of design for concordant profiles developed from external loading conditions of the structure; for example, tendon profile corresponding to the bending moment diagram due to any possible loading on a rigidly supported statically indeterminate structure. Knowing all the loading conditions, the maximum and minimum bending moment envelopes can be found, and also the values for the maximum live-load-moment variation in the various sections of the structure. With specified stress limits and choice of section shape, the limiting zone may be determined with the introduction of the dead load moments. With that it is possible to find concordant tendon profile which remains within the limited zone. This is easy in the case of continuous beams, but, in the case of frames, the concordant profile has the added difficulty that the shortening of the members due to prestressing must not introduce support reactions. Authors clarify the proposed method with two examples, one for a beam of uniform rectangular section continuous over two spans, and another for a two-pinned portal frame.

A comparison is made between a simply supported and a continuous beam, showing that the use of continuity is advantageous only when large dead loads occur. It is also shown that adoption of alternating long and short spans does not lead to economy.

Considering the unfavorable opinions expressed on concordant profiles by such eminent men in the field as Ives Guyon and Fritz Leonhardt, reviewer believes that authors should complete their work by comparing their process of design of the prestressed reinforcement with other methods, such as "adaptation" by means of plastic hinges proposed by Guyon.

J. L. Delpini, Argentina

2523. Dutton, B. L., Some observed strain phenomena of a post-tensioned concrete beam under prestress and flexure, *Proc. Soc. exp. Stress Anal.* **14,** 1, 47–52, 1956.

In a laboratory conducted test on a posttensioned concrete beam, SR-4 strain gages and a Cox and Stevens electrically actuated weighing unit with capsule inserted between a hydraulic jack and the beam were the instrumentation devices used in measuring stress-strain phenomena under cycles of prestressing.

Plastic flow in the concrete, and apparent strain-consolidation of the concrete crystalline structure, were evident from the observations. Under both prestress and flexure loadings, variation in elastic moduli, deflection, and camber were of interest.

Flexural loading of the beam resulted in extension of the pretensioned wire.

Included are data on strain in upper and lower fibers, camber under prestressing load, and deflection and elongation of prestressed wire under flexural loading.

From author's summary

2524. Barber, A. D., Weiner, J. H., and Boley, B. A., An analysis of the effect of thermal contact resistance in a sheet–stringer structure, *J. aero. Sci.* **24,** 3, 232–234 (Readers' Forum), Mar. 1957.

Authors investigate the thermal contact resistance of aircraft sheet-stringer structures under transient heating conditions by devising an idealized one-dimensional model. The Laplace transformation is used to solve the resulting differential equations. It is shown that, for slowly varying heat inputs, a high thermal conductance at the joint is effective in reducing the maximum thermal stress, while for rapid pulses even a perfect thermal contact produces almost no stress alleviation.

A. J. Chapman, USA

Failure, Mechanics of Solid State

(See also Revs. 2427, 2499, 2562, 2563, 2564, 2565, 2566, 2567, 2568)

2525. Valluri, S. R., Effect of frequency and temperature on fatigue of metals, *NACA TN* 3972, 15 pp., Feb. 1957.

Some properties of ductile metals which are exhibited under fatigue loading may be described in a qualitative manner on the basis of a physical model that is familiarly called the linear solid. On this basis it seems possible to conclude that observed critical temperatures are simply temperatures associated with corresponding frequencies of fatigue stressing above which the fatigue behavior changes.

From author's summary by W. J. Anderson, USA

2526. Lundberg, B., and Eggwertz, S., The relationship between load spectra and fatigue life, *Flygtekn. Försöksanst. Medd.* **67,** 32 pp., March 1956.

Cumulative fatigue damage to transport and fighter aircraft is considered in a comprehensive manner. Available data are reviewed for number of cycles and magnitude of gust loads on transport aircraft and maneuvering loads on fighter aircraft.

A recommended load spectrum (straight line on semilog plot) is given. The effect of mean stress on fatigue life is discussed, and although it is pointed out that for fighter aircraft the mean load may not be constant, the cases considered assume that positive and negative parts of the load spectra are equal. Authors show that the load spectra for fighters and transports overlap considerably and emphasize the great importance of the slope of the load spectrum line. The effect of weight reduction in improving life for given acceleration levels is presented.

The results presented in the paper make it possible to standardize the load spectra for program tests in the form of straight lines on semilog paper, the slope of which is the only significant parameter.

S. Levy, USA

2527. Bear, H. R., and Butler, R. H., Preliminary metallographic studies of ball fatigue under rolling-contact conditions, *NACA TN* 3925, 38 pp., Mar. 1957.

This initial metallographic investigation includes macroscopic and microscopic studies of representative samples from each lot of balls tested in the rolling-contact fatigue spin rig. SAE 52100 standard bearing steel and AISI M-1 tool-steel balls were investigated at both room temperature (80 F) and at 200 to 250 F. Fiber direction, inclusions, and chemical segregation are found to contribute much toward fatigue failures and life scatter.

Structures in the maximum-shear-stress area were stable at room temperature, but unstable when tested at 200 or 250 F. Thus, both SAE 52100 and AISI M-1 steel are sensitive to a small temperature increase.

All ball fatigue failures were visually similar and usually progressed from shear cracks. Various failure origins are found; these include chemical segregation, inclusions, surface pitting, and structure changes. Many incipient cracks are found which originate at inclusions. The ball pole regions where fiber direction is perpendicular to the surface and where inclusions and chemical segregation are more prominent were weaker areas in fatigue in the initial test runs. All failures were of the same type as those found in full-scale bearings.

From authors' summary

2528. Lazar, L. S., Accelerated fatigue of plastics, *ASTM Bull.* no. 220, 67–71, Feb. 1957.

The Prot progressive loading method appears to be a promising accelerated technique for determining the fatigue limits of plastics, which should be investigated further.

From author's summary

2529. Yokobori, T., A theoretical criterion for the fracture of metals under combined alternating stresses, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–21, 4 pp.

A criterion for fracture under combined alternating stress is developed from a dislocation model for the formation of a crack. The model resembles that postulated by Mott and developed by Stroh. Dislocations emanating from a Frank-Read source move under the action of shear stress and pile up against a barrier. The barrier is considered to be a hard particle or inclusion which itself contributes a stress concentration aiding in the formation of a crack. The theoretical results are compared with data taken from the literature on the fatigue of brass, cast iron, and steel under combined alternating stress. Theory and experiment show good agreement. Differences in the behavior of various metals in fatigue would, according to this theory, be attributable to differences in the elastic constants, the mean-free path between hard particles, and the severity of the stress concentrations around the particles themselves.

R. B. Shaw, USA

2530. Williams, M. L., On the stress distribution at the base of a stationary crack, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56–A–16, 6 pp.

Using polar coordinates, author satisfies the conditions of the free boundary along the surface of a V-notch for symmetric and antisymmetric cases of stress distributions. The strain-energy density gives new aspects for yield conditions.

H. Neuber, Germany

2531. Lubahn, J. D., Effect of temperature on the fracturing behavior of mild steel, *Welding J.* **35,** 11, 557–568, Nov. 1956.

Fracture properties, including strength, energy-absorbing capacity, ductility (local plastic strain preceding crack initiation), and the amount of gradual tearing preceding brittle crack propagation by cleavage, were measured in specimens cut from both the rolling and thickness directions of a 4-in. SAE 1020 steel plate. Temperatures ranging from -195 C to 100 C (and 250 C in some

cases), loading rates corresponding to slow bend and tensile tests and standard impact tests, and various biaxialities obtained using tensile specimens, narrow and wide unnotched beams, and notched beams, were employed. The tensile strength increased as the temperature was lowered, and the bending strength increased until the temperature was lowered below -150 C. The other properties showed rapid reductions at various temperatures depending upon the rate of loading and biaxiality. The ductility in the normal direction was much lower and more erratic than in the rolling direction, but the strengths in the two directions are essentially the same except below - 150 C.

Results show that "transition temperature" in a Charpy impact test is related to the temperature range where the metal is losing its ability to gradually tear (without cleavage), while "transition temperature" in an unnotched impact bend test is related to the temperature range where the metal is losing its ductility. The latter temperature is about 100 C lower than the former one.

There is nothing about these particular test results to indicate that mild steel would be either weak or brittle at temperatures above -50 C; that is, under normal conditions of service. Catastrophic service failures are discussed in terms of other factors not present in these tests, such as size, notch sharpness, and secondary loads. H. T. Corten, USA

2532. Mansfield, W. S., Crankcase explosions: Development of new protective devices, *Inter. Shipbldg. Progr.* **4,** 30, 82–106, Feb. 1957.

2533. Bredzs, N., and Schwartzbart, H., Triaxial tension testing and the brittle fracture strength of metals, *Welding J.* **35,** 12, 610–615, Dec. 1956.

Data are presented on the effect of joint thickness on the tensile strength of mild steel and drill rod brazed with silver and copper. From authors' summary

2534. Butler, R. H., Bear, H. R., and Carter, T. L., Effect of fiber orientation on ball failures under rolling-contact conditions, *NACA TN* 3933, 35 pp., Feb. 1957.

Two series of rolling-contact fatigue tests were conducted in a bench-type rig developed at the NACA Lewis Laboratory. In one series, ½-inch balls made of SAE 52100 and AISI M-1 steel were tested at an ambient temperature of 80 F and at maximum Hertz stresses up to 720,000 psi. The effect of fiber orientation was observed with the ball track restricted to passing directly over the poles or coincident with the equator. These tests were conducted using a synthetic lubricant.

To obtain additional evidence 29 failed balls from tests of 150 balls conducted to determine the stress-life relation of the rig were macroetched to determine failure location. These 9/16-inch balls were tested at stresses of 600,000 to 750,000 psi at room temperature using a mineral oil lubricant. Parallel flats 3/16 inch in diameter were ground on each ball to assure random track orientation.

Analysis of failure position showed that approximately twice as many failures occurred in the polar areas as would be expected if the ball were of uniform fatigue strength over the entire surface. Most early failures resulted from polar weakness (open end grain), large inclusions, or macroscopic corrosion spots.

From authors' summary

2535. Pomeroy, C. D., A simple method for the assessment of coal strength, *J. Inst. Fuel* **30,** 193, 50–54, Feb. 1957.

The development of a simple empirical strength test for coal is described. The test consists of the degradation of a closely graded coal sample inside a closed cylinder by a succession of hammer drops. An impact strength index is defined as the percentage of coal remaining in the original size interval after degradation. The test parameters are extremely important and experiments have shown the most suitable size range of the fragments, the magnitude of the weight, and the number and height of the drops. The impact strength indices of nine distinct coals are shown to correlate closely with the mean compressive strengths of one-inch cubes of the coals.

From author's summary

2536. Schepers, A., and Licht, F. R., Statistical comparison of notch toughness values as measured on two different pendulum impact testing machines (in German), *Stahl Eisen* **77,** 4, 218–221, Feb. 1957.

Report no. 1066 of the Committee for Materials of the Verein Deutscher Eisenhuttenleute. Testing results on DVM test bars cut from the normalized plain carbon steels, type C 15 with 0.15% C and C 60 with 62% C. Determination of the notch toughness on two different pendulum impact testing machines with a maximum strength of blow of 15 and 30 kgm. Investigation of the reliability of the differences found by statistical methods and their interpretation. From authors' summary

2537. Kozinets, P. V., The dynamic action of a locomotive on the track in the case of wear of tires (in Russian), *Trudi Kharkovsk. politekhn. in-ta* **5,** 2, 183–189, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2690.

Test curves are given of the character of the wear of the wheel tires of locomotives of the series FD and SO after a run of the order of 50,000 km, and the formula for these curves are presented in the form of a trigonometric series.

Further, the oscillation of the dynamic loading on the rail is determined having regard to the elasticity of the springs and of the rail. A general formula of the dynamic load on the track is suggested, according to which the curves of the loading were plotted in the case of different velocities of motion, calculated for a locomotive of the series FD.

Their analysis explains the causes of unsteady motion of a locomotive at a speed above 55 km/h and shows that the dynamic load on the rail from the leasing wheels may reach a considerable value, of the order of 7 to 9 T.

Courtesy Referativnyi Zhurnal M. K. Kristi, USSR
Translation, courtesy Ministry of Supply, England

Rheology (Plastic, Viscoplastic Flow)

(2419, 2452, 2466, 2504, 2514, 2527, 2548, 2557, 2572, 2573, 2588, 2712, 2713)

2538. Taylor, G. I., Strains in crystalline aggregate, Deformation and flow of solids, Colloquium Madrid, Sept. 26–30, 1955, 3–12. Berlin, Springer Verlag, 1956.

Paper reviews author's previous work on the calculation of the tensile yield stress of face-centered cubic aggregates from single crystal data. An outline of the method is presented, and reference is made to the papers of Bishop and Hill on the same subject. Based on experimental facts observed by the author and Elam in single iron crystals, a method is proposed for predicting the tensile yield strength of body-centered aggregates. As in the case of face-centered aggregates it is assumed that each grain undergoes the same uniform strain, and that the actual active set of shears is that for which the sum of their magnitudes is least. The problem is reduced to the calculus of the true minimum value of three continuously changing parameters. No application of the proposed method is made. The method is not suitable to all the body-centered aggregates but it is restricted to those in which the shear stress required to operate a shear strain in a plane of glide is very nearly independent of the orientation of the plane.

C. A. Sciammarella, Argentina

2539. Olszak, W., On a classification of nonhomogeneous elastoplastic bodies, *Bull. Acad. Polonaise Sci. Cl. IV* **4,** 1, 29-35, 1956.

Paper outlines the foundations of the theory of small elastoplastic deformations in nonhomogeneous bodies when the state of stress is practically not influenced by the strain rate.

From author's summary by J. Heyman, England

2540. Moshnin, E. N., Investigation of plastic bending (in Russian), Elementy. teorii. i. novye protseosi obrabotki metallor davleniem. Tsentr. n-i. Inst. tekhnol, i. mashinostr. kn. 62, Moscow, 27-101, 1954; *Ref. Zh. Mekh.* Rev. no. 390. 1956,

The theoretical and experimental investigation of plastic bending.

In the first case, pure bending is examined, and a simplified curve of the true stresses, consisting of three rectilinear sections, is used. An investigation is made of pure volumetric plastic bending for a wide beam of rectangular section, when the relationship of the intensity of the stresses to the intensity of the deformations does not increase. The intensity of the deformations was assumed to be 1.5 times the relative true deformation. The distribution of the main stresses, the radii of the neutral layers of stresses and deformations, the lowering of the height of the beam, the bending moment, and the springing angle on unloading, were all determined. For the first and second section of the diagram, the calculation formulas were determined for the loading moment, the angle of springing, and the residual stresses. Numerical estimates were made of the influence of the elastic zone, of the hardening of 15.45 steels. Comparison of the formulas for determining the bending moment with earlier formulas shows a considerable difference. The design of a test machine is described, which enables bending of the specimens to be performed to a relative radius of 3, in conditions close to pure bending, and to obtain oscillograms of the relationship of the bending moments to the curvature.

More than 200 experiments on pure and on numerous repeated bendings of specimens of carbon steel, brass, and duralumin. The greatest deviation of the experimental curves for the relative bending moments, from the theoretical values, amounts to 15%.

Courtesy of Referativnyi Zhurnal R. I. Nadeeva, USSR
Translation, courtesy Ministry of Supply, England

2541. Hill, H. H., Effects of cambering of steel WF beams, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 1, (*J. Struct. Div.*), Pap. 1146, 15 pp., Jan. 1957.

Author demonstrates that the stresses remaining after camber of a beam by cold working should be considered in design applications. A method is described for determining the stresses both before and after a load system is applied. Present state of knowledge dictates solution by trial and error. Further, the calculation of the moment to produce a required camber is demonstrated using beam deflection methods for the plastic condition.

The construction of curves is illustrated for a steel WF beam from which the residual stresses are revealed for any camber on reloading. P. Whitton, England

2542. Hodge, P. G., Jr., and Perrone, N., Yield loads of slabs with reinforced cutouts, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-7, 8 pp.

Paper gives method for theoretical prediction of upper and lower bounds for yield loads of square slabs with variously shaped centered cut-outs with or without edge reinforcements. Slab and reinforcement are assumed of perfectly plastic material satisfying Tresca yield condition; yield load is defined as load at which small load increment produces large deformation increment. Comparison is made with available experimental data, showing, in general, good results. Reviewer remarks that 3 of the 5 serious discrepancies in table 1 concern test specimens with eccentric reinforcements, no account of eccentricity being taken in theory. Since computation of upper bound is very simple, authors recommend, for design, use of upper bound with 10% reduction.

F. J. Plantema, Holland

2543. Makushin, V. M., On one of the conditions of plasticity (in Russian), *Vestnik Mash.* **35,** 9, 6-8, Sept. 1955.

2544. Ivanova, V. S., Extrapolation of creep test data (in Russian), *Teploenergetika* **3,** 1, 26-28, Jan. 1956.

2545. Paslay, P. R., and Slibar, A., Flow condition and deformation law of viscoplastic materials (in German), *Öst. Ing.-Arch.* **10,** 4, 328-344, 1956.

In the first part of the paper, the stress-strain law of the Bingham solid is established in tensor form. Authors do not seem to be aware that this law was already formulated by Hohenemser and Prager [*ZAMM* **12,** 216-226, 1932]. The second part of the paper contains various applications of this stress-strain law: flow between parallel plates, flow through tube of circular cross section, Couette flow, and flow of viscoplastic lubricant in a thrust bearing.

W. Prager, USA

2546. Chow, T. -S., On an initial value problem for flow of a viscous incompressible fluid in an unbounded region, *J. rational Mech. Analysis* **5,** 2, 263-276, 1956.

Article seems to deal with transverse inertial waves which are almost periodic in space but not in time. Given initial velocity distribution expressible as trigonometric series, expression is derived for interaction in time between different waves in pairs; and decay of the total velocity field with time is expressed as power series in t with coefficients which are negative exponentials of νt, ν being kinematic viscosity.

Reviewer found the article difficult because of lack of references, definition of "wave number vector", physical interpretation, and summary. M. Mooney, USA

2547. Broer, L. J. F., On the hydrodynamics of viscoelastic fluids, *Appl. sci. Res.* (*A*) **6,** 2/3, 226-236, 1956.

In this mathematical paper, author expresses hydrodynamical properties of a linear viscoelastic fluid in the form:

$$\sigma_{ik} + \tau \frac{d\sigma_{ik}}{dt} = \mu \dot{D}_{ik}$$

where σ_{ik} is the stress deviator, $\dot{D}_{ik}$ is the velocity-strain deviator, and d/dt is the material time derivative for a material of single relaxation time τ and viscosity coefficient μ. This expression is used to derive solution to certain specific problems: periodic solutions of linearized equations; flow in cylindrical tube; slow, steady motion; flow in a film; "to obtain at least an idea of the influence of elasticity on viscous flow," in words of author.

Reviewer notes this equation lacks invariance properties appropriate to such a viscoelastic fluid. This, together with approximations made in analysis, make it likely that results do not include more interesting of these effects. No reference is made to results published in recent years [e.g., Reiner, *Amer. J. Math.* **67,** p. 350, 1945; Rivlin, AMR **1,** Rev. 1024; Loring, AMR **4,** Rev. 1186; Irmay, AMR **8,** Rev. 1980.

J. T. Bergen, USA

Material Test Techniques

(See also Revs. 2399, 2536, 2554, 2555)

2548. Watts, A. B., and Ford, H., On the basic yield stress curve for a metal, *Instn. mech. Engrs. Proc.* **169,** 58, 1141-1156, 1955.

The yield stress or flow curve of a metal can be determined accurately by the plane compression test using smooth parallel dies, and related to cold rolling. Tests were performed on high-conductivity copper, but are believed generally applicable.

Optimum test conditions as regards lubrication, loading increments, ratio of die breadth to strip thickness, and strip width were established. G. V. Smith, USA

2549. Gordeev, V. A., The investigation of the elastic properties of textile materials under dynamic strain by a vibration method (in Russian), *Tekstiln. prom-st'* no. 1, 37-41, 1955; Rev. no. 1818, *Ref. Zh. Mekh.* 1956.

An apparatus is described for testing the elastic properties of cotton yarns, glass filaments, and woolen yarns, founded on the principle of measuring the vertical vibrations of a weight suspended on the test thread.

Test methods are described and experimental results presented. For all materials excepting glass filaments, the value of the coefficient of elasticity determined by this dynamic method is found to be considerably higher than found by the static test.

Courtesy of Referativnyi Zhurnal A. V. Matukonis, USSR
Translation, courtesy Ministry of Supply, England

2550. Vishnitskaya, L. A., Methods of measuring the equilibrium modulus of rubber (in Russian), *Trudi N.-i. in-ta rezinovoy prom-sti* no. 1, 53-61, 1954; Rev. no. 1822, *Ref. Zh. Mekh.* 1956.

To determine the equilibtium modulus of hyperelasticity E from the relationship $\sigma = E_\infty \epsilon$, the true stress values σ are measured with a constant strain ϵ in the sample, in the equilibrium condition. The instrument used, and its calibration, are described. Samples, method of evaluating results, and the experimental method are discussed for both rigorous and approximation measurements.

Courtesy of Referativnyi Zhurnal V. I. Novikov, USSR
Translation, courtesy Ministry of Supply, England

2551. Prus, A. A., A new machine for torsion tests on wire (in Russian), *Zavod. Lab.* **21,** 4, p. 489, 1955: Rev. no. 1864, *Ref. Zh. Mekh.* 1956.

A description of the layout and construction of a machine with a pendulum for measuring the torsional moment and a separate meter for the angle of twist of the sample. This latter is determined as the difference of the angles of rotation of two gear wheels attached on the wire sample under test; which excludes distortion of the readings by the effect of the machine grips. A registering device is incorporated.

Machines have been built on this principle up to 40 - 400 kg/cm.

Courtesy of Referativnyi Zhurnal S. M. Zasedatelev, USSR
Translation, courtesy Ministry of Supply, England

2552. Rozenblyum, V. I., Relaxation tests of metals (in Russian), *Heat energetics no.* 10, 16-19, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 3247.

Theoretical investigation of I. A. Oding's method for tests on the relaxation of annular specimens. Using L. M. Kachanov's theory of aging ["Some problems of the theory of creep," GTTI, 1949] and solving, by the approximate variation method of L. M. Kachanov, the problem of the relaxation of stresses in a ring, author finds that the relaxation curves of an annular and cylindrical specimen should coincide, if the corresponding initial stresses are selected.

A satisfactory coincidence was noted of the relaxation curves thus obtained for four types of steel with the result of their calculation according to creep curves.

I. A. Oding's formula [TSNIITMASH, 1949, book 23] gives a slightly increased stress value (on an average ~ 7%).

Courtesy of Referativnyi Zhurnal V. S. Ivanova, USSR
Translation, courtesy Ministry of Supply, England

Mechanical Properties of Specific Materials

(See also Revs. 2399, 2520, 2521, 2528, 2548, 2549, 2550, 2574)

Book—2553. Dawihl, W., A handbook of hard metals, New York, Philosophical Library, Inc., 1956, viii + 162 pp. $10.00.

Hard metals derive their importance from the hardness of the carbides of metals with high melting points, which are their chief constituents. They are manufactured into suitable moulded shapes, either by sintering the carbides in the form of powder or by melting. In the course of development, the alloys produced from hard carbides by sintering have proved to have by far the greater technical importance. The hard-metal technique has therefore become a section of the general sintering technique.

The first part of the book deals with the scientific principles of sintering in order to help an understanding of the production of hard metal in relation to other developments in the application of the sintering technique. The second part describes the technical production of hard metals.

Reference is made in detail to the experimental methods and results of many other investigators in order to assist further development. From author's preface

2554. Yoshizawa, T., Studies on the Erichsen test of sheet metals (in Japanese), *Trans. Soc. mech. Engrs. Japan* **23,** 127, 225-229, Mar. 1957.

Influence of decrease in specimen width on Erichsen value of sheet metals is studied experimentally. Materials tested are low-carbon steel, brass, copper, aluminum and its alloys of varying thickness. Tests indicate that Erichsen value obtained using standard tester is not affected practically by the width of specimen, if the specimen is clamped tightly (though "tightly" is not a term precisely specified) and its width is not less than 40 mm.

Y. Yamada, Japan

2555. Brenner, S. S., Tensile strength of whiskers, *J. appl. Phys.* **27,** 12, 1484-1491, Dec. 1956.

Tensile tests have been performed on whiskers of iron, copper, and silver 1.2 to 15 μ in diameter. The strongest whiskers which were less than 4 μ in diameter exhibited resolved elastic shear strengths of from two to six per cent of their shear moduli. Stress-strain determinations on iron have shown that large deviations from Hooke's law occur beyond two per cent strain. As the whiskers increase in size, their strengths decrease with considerable scatter. From author's summary

2556. Steele, M. C., and Eichberger, L. C., Nonhomogeneous yielding of steel cylinders. I. Mild steel, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-39, 10 pp.

Experimental information on the mechanism of yield and the associated strains is presented for mild-steel cylinders (2:1 diameter ratio) overstrained by internal fluid pressure. A limited number of Lueders' lines develop and propagate through the cylinder wall according to distinct patterns. The strains vary circumferentially in keeping with the nonhomogeneous mechanism of yield. Comparison with homogeneous plasticity theories shows good agreement for circumferential strains provided a correction is made for the material yield stress. Axial strains are essentially elastic. Creep under maintained constant load is discussed in relation to strain and Lueders' line movement.

From authors' summary

2557. Manjoine, M. J., Creep characteristics of Type 347 stainless steel at 1050 and 1100 F in tension and compression, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-40, 8 pp.

Cold-drawn and stress-relieved Type 347 heavy-wall tubing flows plastically at service temperatures (1050-1100 F) when subjected to a stress below the 10,000-hr rupture strength. Pre-

cipitation induced by the strain and temperature conditions causes an extended period of abnormally high creep resistance. The duration of this period increases with decreasing stress and is longer for compression than for tension. The creep and rupture strengths for service duration over 10,000 hr are poorer than those reported for Type 347 annealed bar stock.

From author's summary

2558. Savelyev, L. I., The characteristics of the limiting loading cycles and real stress values in steels 45 and 30 XMA (in Russian), *Vestnik Mash* no. 2, 14–17, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1850.

An investigation of the relationship between the magnitude of the cyclic amplitude σ_v and the mean cyclic stress σ_m. From tests made on steels 45 and 30 XMA, the linear relationship

$$\sigma_v = \sigma_1 \left(1 - \frac{\sigma_m}{s_k}\right)$$

is established, in which s_k is the real rupture strength. It is demonstrated that there is a satisfactory relationship between this expression and various experimental data given in the literature; the endurance limit, calculated from a pulsating cycle by the expression

$$\sigma_0 = \frac{2\sigma_{-1}\, s_k}{\sigma_{-1} + s_k},$$

differs from the experimental data by 2 – 5%.

It is pointed out that by determining the endurance limit for a symmetrical cycle σ_{-1} and the true rupture limit s_k it is possible to establish with sufficient accuracy, for the steels tested, the values of the cyclic amplitude σ_v for different values of the mean stress σ_m, utilising the linear relationship between them.

Courtesy of Referativnyi Zhurnal L. A. Kozlov, USSR
Translation, courtesy Ministry of Supply, England

2559. Barlow, D. A., The formability of aluminum alloys, *J. Amer. Soc. nav. Engrs.* **68,** 4, 744–766, Nov. 1956.

Forming operations where limits are set by material rather than tools were classified into five chief types: Stretching or tensile, shrinking or compressive, bending, deep drawing, and ironing. Discussion of each type is supplemented with comparisons between theoretical and experimental values to illustrate that the formability can be predicted with sufficient accuracy from stress-strain curves. Author was careful to point out the need for more accurate yield and fracture criteria as well as more accurate calculation procedures for cup-wall strength in deep drawing. Operations such as tube bending, rectangular shell drawing, or shrinking of cylindrical parts are not included. J. Frisch, USA

2560. Mather, W. B., Mineral raw materials for atomic energy, Report by the Atomic Industrial Forum, Inc., 260 Madison Ave., New York 16, New York, 70–89, May 10–11, 1956.

The atomic industry in its present infancy employs more than 25% of the elements known to science. This paper deals with the major raw materials for twenty-two of these elements. These have been arbitrarily chosen but they currently play a major role or could be of future significance in the development of atomic energy, radiography, and radioactive tracers.

In the discussion of individual elements the following pertinent data are presented: abundance in the crust of the earth; ore minerals, their composition, geologic occurrence and geographic distribution; world and domestic production and reserve statistics.

The following elements are discussed: atomic fuel and breeder elements—uranium and thorium; cladding and alloying elements with atomic fuel—zirconium, aluminum, and iron (stainless steel); coolants—helium, sodium potassium, lead, mercury and bismuth; moderators—beryllium and graphite; control elements—boron, cadmium, hafnium, and gadolinium; reactor shields—lead and iron; radiography—cobalt; cesium and iridium; tracer elements—iodine and sodium; fusion reactor fuel—lithium.

It is also pointed out that progress in materials technology comprises the most significant technological advance recently achieved in the nuclear energy field. From author's summary

2561. Smith C. O., Materials problems in nuclear reactors, *J. Amer. Soc. nav. Engrs.* **69,** 1, 37–44, Feb. 1957.

2562. Cunningham, J. R., and Ivey, D. G., Dynamic properties of various rubbers at high frequencies, *J. appl. Phys.* **27,** 9, 967–974, Sept. 1956.

Paper presents shear wave measurements on several rubbers, e. g., GR-S, Butyl, Hevea, Hycar and Paracril, as a function of temperature and frequency. From shear wave velocity and attenuation and the corresponding bulk wave data (reported previously), the dynamic shear, bulk and Young's moduli, and their associated viscosities, were calculated. Comparison of these high-frequency results with low-frequency Young's modulus data on the same materials gives information over many decades of logarithmic frequency, and from this the distribution of relaxation times was determined. F. Chmelka, Austria

2563. Nakagaki, M., and Heller, W., Effect of light scattering upon the refractive index of dispersed colloidal spheres, *J. appl. Phys.* **27,** 9, 975–979, Sept. 1956.

For the exact size determination of colloidal dispersed spheres an equation by Zimm and Dandliker on the effect of light-scattering upon the refractive index of colloidal dispersions of spheres is transformed to give a new mixture rule from which the refractive index of colloidal spheres, to be expected in absence of light-scattering, can be calculated. The latter is needed for particle size determinations in colloidal solutions from light-scattering measurements to be evaluated on the basis of the Mie theory. A graphical method is worked out which allows one to obtain simultaneously both the refractive index and the diameter of the particles. F. Chmelka, Austria

2564. Bueche, A. M., and White, A. V., Kinematographic study of tensile fracture in polymers, *J. appl. Phys.* **27,** 9, 980–983, Sept. 1956.

Tensile fractures of silicone rubber, irradiated polyethylene, Plexiglas II, and aluminum foil were observed during their occurrence by taking high-speed motion pictures. Fractures started internally in some of the silicone samples, but at the edges of all of the others. The measured velocites with which the cracks grew were found to be in reasonable accordance with theory. After fracture, the ends of the rubber samples contracted with velocities approximately equal to the velocities of longitudinal waves in these samples. F. Chmelka, Austria

2565. Philippoff, W., Flow birefringence and stress, *J. appl. Phys.* **27,** 9, 984–989, Sept. 1956.

Simultaneous measurements of flow birefringence, shear and normal stresses on a 15% solution of polyisobutylene in decalin were performed. They proved that the extinction angle measured in birefringence is identical to the orientation of the principal tensile stress calculated from the normal stress measurements and that the birefringence was proportional to the difference in principal stresses in flow. A detailed discussion of the significance of this result is given with a possibility of a far-reaching generalization of the mechanical behavior of high polymer solutions.

From author's summary by F. Chmelka, Austria

2566. Andrews, R. D., and Rudd, J. F., Birefringence changes during retraction of oriented polystyrene monofilaments. I. Changes of average birefringence, *J. appl. Phys.* **27,** 9, 990–995, Sept. 1956.

The changes in average birefringence during retraction have been measured at 85 C for four different oriented polystyrene monofilaments. Birefringence decay is relatively more rapid than the length decrease in all cases. Birefringence-length relationship seems to be essentially independent of retraction temperature. One of the filaments showed an interesting change in sign of the birefringence in the final stages of the retraction. The birefringence decay data for the four filaments could not be reduced to any universal curve by plotting either birefringence or relative birefringence against any simple functions of length or extension. Analyzing the data in terms of a distribution of retardation times, by assuming that birefringence decay and length decrease are in some constant ratio for each retardation time, also failed to reduce the data to a single common curve. Internal stress may be an essential parameter for a proper characterization of the birefringence.

From authors' summary by F. Chmelka, Austria

2567. Rudd, J. F., and Andrews, R. D., Birefringence changes during retraction of oriented polystyrene monofilaments. II. Changes in radial distribution of birefringence, *J. appl. Phys.* **27,** 9, 996–1002, Sept. 1956.

The radial distribution of birefringence, $\Delta(r)$, has been measured in Filament #16 at a series of time values up to 600 hrs, during retraction at 85 C. The birefringence distribution was obtained by cutting wedges on the end of the filament samples and analyzing the optical interference pattern down the center line of the wedges, under a polarizing microscope. The rates of birefringence decay at different points along the radius are not the same, or even proportional. Birefringence values near the center of the filament change from negative to positive sign in the long time region, while values near the exterior surface remain negative throughout. Values of the diameter average birefringence calculated from $\Delta(r)$ are in close agreement with values obtained from direct experimental measurement. A cross-sectional-area average birefringence was also calculated from $\Delta(r)$; this quantity decreases monotonically toward zero, with no transition to positive values in long time region.

From authors' summary by F. Chmelka, Austria

2568. Work, R. N., and Trehu, Y. M., Detailed structure of copolymers from dielectric measurements, *J. appl. Phys.* **27,** 9, 1003–1011, Sept. 1956.

The effective dipole moment of each polar group in polar-polar or polar-nonpolar copolymers is expressed in terms of the moment of an equivalent isolated polar group and the average of the vector sum of the moments of all of the polar groups surrounding it. If effects of short-range forces leading to angular correlations of dipole pairs are neglected, except for interactions between nearest neighbors along the chain, an expression for the average of the effective moments of the two types of polar groups present, $(\mu^2)_{Av}$, can be written as a function of the composition of the copolymer. Onsager's equation for the dipole moments of molecules in mixtures of polar liquids has been modified to express the average of the effective moments of the polar groups present in terms of the dipolar contribution to the dielectric constant, $\epsilon_s - \epsilon_\infty$. Using this equation, values of $(\mu^2)_{Av}$ have been calculated from measurements of $\epsilon_s - \epsilon_\infty$ for several copolymers of poly-(*p*-chlorostyrene-styrene) representing the whole range of copolymer composition. Measurements were made on bulk copolymers at temperatures above the glass transition temperature. A curve has been fit within experimental error to the calculated values of $(\mu^2)_{Av}$ over the whole range of copolymer composition. This indicates that within the limits of error of this work only nearest neighbors on the polymer chain contribute to the effective moments of the polar groups. From authors' summary by F. Chmelka, Austria

Book—2569. Quak, K., Technical knowledge. Technical material. I. Structure of materials, stones and earth, wood and synthetic materials [Technisches Wissen. Technische Stoffe. I. Aufbau der materie, Steine und Erden. Holz. Kunststoffe], 3rd ed., Leipzig, Fachbuchverlag, 1956, xiii + 457 pp. + 1 chart. DM 18.

2570. Mikhailov, N. N., The increase in density of glasses under high pressure (in Russian), *Pridoda* no. 2, 82–85, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1807.

Determination of the residual increase in density of glasses was effected on samples in the forms of disks of a diameter of 5.8 mm and a thickness of 0.15–0.24 mm. Compression was effected in a 75-ton hydraulic press with conical dies and inserts of tungsten carbide.

At pressures up to 10,000 atm, the glasses behaved as ideally-elastic materials; at pressures above 10,000 atm, soda-silicate glasses with 10, 23, and 31% Na_2O, showed residual increase in density. With increasing Na_2O content, this residual increase in density became greater. For a glass ("Vikor") with 96% SiO, 3% B_2O_3 and 1% other oxides, the increase in residual density at 20,000 atm was 65%. The critical pressure in this case was 80,000 atm. Pure, vitrified silica showed 7.5% increase in residual density only at a pressure of 200,000 atm. For vitrified boron anhydride, the residual increase in density at 40,000 atm was only 4%. The rate of increase of the (applied) pressure was 2000 atm/sec; with increased rate of application of the test pressure, the residual increase in density increases, which is explained by the author as an increase in temperature. When glasses were annealed at 310° for 28 hours, the residual increase in density disappeared; while for quartz glass annealed in vacuum at 430° for 1 hour, the density of the material remained higher than that of the starting material. According to the results of x-ray analysis, this increase in density of the glass is due to a phenomenon of the nature of folding in the lattice structure of the glass, with release of large forces retaining the displaced atoms in their new positions at room temperature; with increasing temperature these forces are overcome and the glass returns into the initial state.

Courtesy of Referativnyi Zhurnal N. S. Alekseev, USSR
Translation, courtesy Ministry of Supply, England

Plasticity, Forming and Cutting

(See also Revs. 2387, 2464, 2535, 2541, 2548, 2554, 2559)

2571. Miller, G. E., Special theory of ultrasonic machining, *J. appl. Phys.* **28,** 2, 149–156, Feb. 1957.

Machinery rate equation is derived for solid circular tool with puddled slurry, based on degree of plastic deformation, speed of particles, and work-hardening capacity of material. Theoretical relationship between variables is confirmed by experiment.

R. N. Arnold, Scotland

2572. Ota, T., Shindo, A., Fukuoka, H., and Sugimoto, K., Compression of a wedge by a flat rigid die (in Japanese), *Trans. Soc. mech. Engrs. Japan* **23,** 127, 242–249, Mar. 1957.

An unsymmetrical slip-line field for a wedge compressed by a smooth flat die is presented which gives smaller die load than Hill's two symmetrical ones [AMR **4,** Rev. 2471]. The corresponding three slip-line fields for narrower wedges for which above fields do not hold are discussed; a symmetrical field due to authors and an unsymmetrical one suggested by Green [AMR **4,** Rev. 4148] are shown to be theoretically complete; and for a remaining symmetrical one, upper and lower bounds of die load are obtained. The influence of friction between wedge and die is also discussed. The theoretical mode of deformation under frictional conditions which gives a minimum die load agrees well with results of authors' experiment with lead wedge, lubricant being graphite in grease.

Reviewer believes the present paper contains an important contribution to the subject. Y. Yamada, Japan

2573. Polukhin, P. I., Constrained transverse deformation in rolling (in Russian), *Trudi Sibirsk. metallurg. in-ta* no. 1, 40–59, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1631.

The deformation is investigated of a rolled strip with the roll pressure applied at the middle of the width. The ratio between longitudinal and transverse deformation is influenced by the relationship between the length of the area of deformation l to its width b, and the ratio of the transverse area of the roll elements F_1 to the total cross-sectional area F. The influence of these factors in different combination on samples of different form is investigated. With decreasing ratio F_1/F (l/b being constant), the transverse deformation increases, and the longitudinal deformation decreases.

In a second series of test samples the compressed areas on the edges of the sample (double-tee with thickened web) are additionally investigated. The influence of l/b and F_1/F is the same as in the preceding cases.

The optimum relationships between these factors are determined for obtaining the maximum increase in width.

Courtesy of Referativnyi Zhurnal V. G. Osipov, USSR
Translation, courtesy Ministry of Supply, England

2574. Geront'iev, V. I., Some preliminary conclusions and essential principles in the theoretical and experimental investigation of the shatter strength of coals (in Russian), *Tr. Sovesbch. po koordinatsii issled. v oblasti otdeleniya o massiva ugley i porod.* Moscow, Izd-vo Akad. Nauk SSSR, 64–78, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1843.

Experiments are described on the shattering of cube samples of coals and artificial materials by means of a series of punches in a vertical drop hammer, and under a press. The experiments were accompanied by high-speed cinematic recording of the shattering process.

In addition, in working conditions at the coal face, tests were made on the shattering of coal with two exposed surfaces, by pendulum and rotating hammers, respectively. The experiments showed qualitative identity between the shattering processes under static and impact loads.

The punch first penetrates plastically into the material; then a conical, denser nucleus is formed within the shattered fragments, having slightly convex (bulging) sides, which expands laterally and bursts the surrounding envelope. The cracks propagate with a speed exceeding the speed of impact. The material breaks away in the direction of the lateral bared surface. A flat-ended punch causes more intensive destruction than one of tapered form.

The energy absorption in the shattering process decreases with increasing work of individual impact, and with the rate of impact at constant load. Each impact load has a corresponding optimum distance between the point of impact and the exposed surface of the face, the value whereof increases with the force of the blow. There exists also an optimum impact frequency, but this aspect has been insufficiently elucidated.

M. M. Protod'yakonov, USSR
Courtesy of Referativnyi Zhurnal
Translation, Courtesy Ministry of Supply, England

Hydraulics; Cavitation; Transport

(See also Revs. 2408, 2476, 2518, 2606, 2731)

Book—2575. Press, H., Waterways and harbors. I. Inland waterways and river ports [Wasserstrassen und Häfen. I. Binnenwasserstrassen und Binnenhäfen], Berlin, Wilhelm Ernst & Sohn, 1956, viii + 500 pp.

This is a first volume of a new textbook written by the distinguished author of three volumes on dams and water-power plants [AMR 8, Revs. 2034, 2035, 2036]. Contents: I. Inland waterways, natural and artificial. Regulation of river channels: dikes, cutoffs, embankments. Runoff regulation. Canalization: dams, levees, gates, ship locks, spillways. Navigation canals, bridges, tunnels. Water saving. Navigation lifts. II. River ports. Entrance, dimensions, landing quays and piers. Dockyards.

Text is concise and comprehensive. Drawings are particularly excellent; everyone can understand the content without a thorough knowledge of German language. Descriptions are accompanied by few computations of structures. Extensive bibliography (427 titles) is added, almost entirely German. Book will be of great value for hydraulic and transportation engineers.

S. Kolupaila, USA

2576. Goody, A. J., and Davies, T. V., The theory of symmetrical gravity waves of finite amplitude, IV. Steady symmetrical, periodic waves in a channel, *Quart. J. Mech. appl. Math.* **10,** 1, 1–12, Feb. 1957.

Paper continues the interesting series of papers on symmetrical periodic gravity waves [see Davies, T. V., AMR **5,** Rev. 355; Packham, B. A., AMR **5,** Rev. 3326; and Davies, T. V., AMR **5,** Rev. 3035].

The third paper [AMR **5,** Rev. 3035] gave an approximate solution of the problem of gravity irrotational waves in a channel of finite depth, but no attempt was made there to examine the results numerically. Research is done in the present paper. If the depth of the bed below a trough is b, the amplitude of wave is a, the wave length is λ, and the velocity of the liquid at the point of the bed on the y axis and relative to a fixed frame is U, then, with u and k two parameters, it is possible to establish two formulas of the form

$$E_0(a,b) = E(u,k) \quad F_0(a,\lambda) = F(u,k) \quad D_0(a,U,c) = D(u,k)$$

c being the wave velocity. Knowing the U, a, b, and λ values, it is possible to find c.

Tables have been prepared of four combinations of c, a, λ, and b against u and k, from which it is possible to determine (say) the wave velocity, when the three quantities a, b, and λ are given. An analytical formula is also derived for the relation between a, b, and λ when wave is on the point of breaking.

G. Supino, Italy

2577. Powell, C. J., and Brasfeild, C. W., Downpull forces on vertical-lift gates, *Wuys. Exp. Sta. tech. Rep.* no. 2-447, Rep. 1, Dec. 1956.

Tests were conducted on 1:36- and 1:60-scale models to determine the vertical forces to which the gate leaves will be subjected by the extreme range of headwater and tailwater elevations that may occur at the structure. Flow will be regulated by eleven 44-ft-wide gate bays containing multiple-leaf, vertical-lift gates. The side-bay gates will consist of three 19-ft-high leaves, the three center-bay gates of three 19-ft-high leaves plus a 15-ft-high leaf. Tests showed that the two lower gate leaves would bounce violently when being removed, producing destructive forces in the suspension system. Operation of the lower two gate leaves fastened together and relocation of the air vents eliminated the bouncing; however, the load on the hoisting apparatus was considerably increased. From authors' summary

2578. Zel'geim, G. A., A simplified method of combatting alluvia in channels (in Russian), *Izv. Tbilis. n.-i. in-ta sooruzb. i gidroenergetiki* **7,** 95–101, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2845.

On the basis of M. V. Potapova's method of creating transverse circulation in a flow, a proposal is made for arranging a curvilinear section of the channel which is provided in the convex wave with several fault orifices close to the bottom for combatting and removing the ground alluvia which enter the channel.

Courtesy Referativnyi Zhurnal V. V. Fandeev, USSR
Translation, courtesy Ministry of Supply, England

2579. Sharashkina, N. S., Laboratory investigations of river-bed processes; "The problem of river-bed processes" (in Russian), Leningrad, Gidrometeoizdat, 163–172, 1953; *Ref. Zh. Mekh.* 1956, Rev. no. 2843.

The formation of a river bed in a three-dimensional trough containing sand is described for the beginning of the process to the establishment of a state of equilibrium during variation of the gradients and expenditure of water.

The investigation had a qualitative character, but made it possible to determine the relationships connecting the depth, width, and size of the fractions.

In the flow the formation was observed of stationary transverse waves having width less than the width of the flow "fluid meanders" which contributed to the initial meandering. The formation of the meanders of several terraces and local bases of erosion were traced. In the process of formation of the river bed, the erosion, transfer, and deposit were clearly distinguished.

As a result of the treatment of the mean values the following relationships are proposed

$$\frac{b}{d} = 1.6\left(\frac{q}{d^2\sqrt{gdi}}\right)^{0.83} \quad \frac{b}{d} = 0.32\left(\frac{q}{d^2\sqrt{gdi}}\right)^{0.31}$$

(d is the diameter of the alluvia, b and h the width and mean depth of the line of direction, q the fluid expenditure, i the gradient).

Courtesy Referativnyi Zhurnal I. V. Egiazarov, USSR
Translation, courtesy of Ministry of Supply, England

2580. Winter, H., Contribution to the hydraulic manifold problem, Part II (in German), *Öst. Ing.-Arch.* **10**, 4, 317–328, 1956.

2581. Meyer, E., Some new measurements on sonically induced cavitation, *J. acoust. Soc. Amer.* **29**, 1, 4–8, Jan. 1957.

Two experimental studies of the oscillations of single cavitation bubbles are described. In the first, cavitation is induced at the tip of a miniature hydrophone by focused ultrasound. Oscillographic and spectral analyses of the hydrophone output voltage showed a strong line spectrum consisting of the harmonics of the exciting sound frequency, some weaker lines that were harmonics of subharmonics, and a broader band of energy at the natural resonant frequency of radial oscillation of the bubble. In the second study, the motion of a bubble formed at the end of a vibrating rod was photographed at speeds up to 105,000 frames per second. The photographs showed high frequency radial oscillations superposed upon the principal or Rayleigh oscillations. Schlieren photography revealed the emission of a multiplicity of shock waves upon bubble collapse, indicating that the bubbles do not collapse spherically as a whole.

F. G. Blake, Jr., USA

2582. van Aken, J. A., and Tasseron, K., Cavitation-erosion theory, tested in practice, with regard to the blades of ship propellers, *European Shipbuilding* **6**, 1, 14–22, 1957.

2583. Vaughan, V. L., Jr., and Ramsen, J. A., Hydrodynamic characteristics over a range of speeds up to 80 feet per second of a rectangular modified flat plate having an aspect ratio of 0.25 and operating at several depths of submersion, *NACA TN* 3908, 23 pp., Apr. 1957.

An investigation has been conducted to determine the hydrodynamic characteristics over an extended range of speeds (up to 80 fps) of a rectangular modified flat plate having an aspect ratio of 0.25 mounted on a single strut and operating at several depths of submersion. Comparisons have been made between these data and data previously obtained over a lower speed range on a similar flat plate having an aspect ratio of 0.25 and having the same planform shape and area but one-half the thickness. These comparisons indicated that, in the absence of cavitation, no significant changes existed at the higher speeds investigated. The trends shown in the previous low-speed tests continued to apply.

At high speeds and high angles of attack for depths of submersion of a quarter-chord or more, cavitation at the leading edge grew strong enough to cause a greater decrease in lift coefficient with increasing speed than would be indicated by the results of the previous investigations and the present investigation at the lower angles of attack.

Over the lower speed range covered by the previous investigations and at a given angle of attack, the lift coefficient was slightly lower for the thick model used in the present investigation than for the thin model previously tested.

From authors' summary

Incompressible Flow: Laminar; Viscous

(See also Revs. 2547, 2604, 2605, 2612, 2619, 2623, 2636, 2638, 2641, 2644, 2721, 2732)

2584. Legendre, R., Separation of laminar three-dimensional flow (in French), *Rech. aéro.* no. 54, 3–8, Nov.–Dec. 1956.

Author stresses that for separation it is not necessary for the flux vector (density times velocity vector) to be singular, and considers points where the components of the flux vector are continuous and bounded, and satisfy the equation of continuity. He studies in detail the different flows when the components (but not all their derivatives) vanish simultaneously. Various kinds of stream surfaces and streamlines are shown to exist in different circumstances.

In the case of an obstacle in which the no-slip condition holds in a real fluid, author shows that this does not mean that obstacle is a singular surface. Indeed, the flux vector on the surface can be expressed simply in terms of a continuous function Z which vanishes on the obstacle although its derivatives do not. He shows that his earlier work can apply equally well for this case, although a streamline on the body must be interpreted as a "limiting streamline." A separation line is then a limiting streamline which passes through a "point of separation" of the body, this being a point through which an infinity of limiting streamlines leave the body. These form a "separation surface" which cuts the body in a separation line.

Exposition is clear but marred by misprints. Reviewer found 39 proof corrections in 5 1/2 pages! Author hardly justifies criticisms of Maskell's work, and indeed seems to agree with him on many points.

J. C. Cooke, British Malaya

2585. Couchet, G., Two-dimensional flow in the presence of a moving body (in French), *Mem. Sci. math.* no. 127, 80 pp., 1956.

This over-long monograph is divided into five chapters, of which the first is concerned with basic formulas and the second with flows without circulation. In the third chapter, unsteady flows in which the circulation is constant are discussed, a condition being found for such flows to be possible. The effect of rectilinear vortexes in the fluid on the forces acting on the obstacle is given in chap. 4. In chap. 5 there is a brief account of experiments to check the results of chap. 3, and the force on an obstacle due to a vortex street is calculated, taking account to some extent of the growth of the vortexes near it.

K. Stewartson, England

2586. Cooke, J. C., On Rayleigh's problem for a general cylinder, *J. phys. Soc. Japan* **11**, 11, 1181–1184, Nov. 1956.

The incompressible Rayleigh problem for a general cylinder has been treated by Batchelor [AMR **8**, Rev. 2075], and extended by Hasimoto [AMR **8**, Rev. 2563; also *J. phys. Soc. Japan* **10**, p. 397, 1955]. Present author gives improved forms for the series solutions for both small and large time, which permit the calculation of

the velocity distribution in the fluid. The skin friction calculated by new series agrees with that found by Hasimoto.

L. Talbot, USA

2587. Agrawal, H. L., A new exact solution of the equations of viscous motion with axial symmetry, *Quart. J. Mech. appl. Math.* **10**, 1, 42–44, Feb. 1957.

Considering the stream function to have the form $\Psi = \nu r^n f(\theta)$, a new exact solution is obtained for the equations of incompressible viscous motion with axial symmetry. In the case $n = 4$, the solution represents the motion in a slightly divergent jet striking a distant wall at right angles. A. R. Mitchell, Scotland

2588. Laird, W. M., Slurry and suspension transport—Basic flow studies on Bigham plastic fluids, *Indust. Engng. Chem.* **49**, 1, 138–154, Jan. 1957.

Paper treats laminar flow of non-Newtonian fluid in annular section. Problems of this type appear in oil industry where flow of drilling fluid in annular space formed by drill pipe and well casing or bore hole must be calculated. Fluid can be considered a Bingham body. This implies "plug flow," that is, the existence of a region (plug) where the shear stress resisting the pressure is insufficient to overcome the yield stress. In the present case, the plug corresponds to an annular region with diameters a and b. An equation is established that gives flow in terms of the two characteristic coefficients of the Bingham body, the dimensions of the pipe, and of a and b. For precise calculations the constants a and b may be determined by a numerical method. For engineering calculations it can be assumed that, at reasonably high pressures, the thickness of the plug becomes negligible; then the two constants reduce to a single one that is expressed in terms of outside and inside diameter of the annular section through which flow is calculated. B. Gross, Brazil

2589. Kidder, R. E., Motion of the interface between two immiscible liquids of unequal density in a porous solid, *J. appl. Phys.* **27**, 12, 1546–1548, Dec. 1956.

Analytical methods are presented for determining motion of the interface between two immiscible liquids of unequal density in a homogeneous, isotropic, porous solid. Viscous two-dimensional flow actuated by gravity and capillarity only is assumed. Using potential theory, a solution is obtained with four impermeable boundary walls by satisfying kinematic and dynamic conditions at the interface, assuming that the interface initially has a smooth and gentle curvature. An application to the motion of a tilted plane interface is given. G. A. Leonards, USA

2590. Domm, U., Vortex streets of minimum stability (in German), *ZAMM* **36**, 9/10, 367–371, Sept./Oct. 1956.

The stability of a two-parameter vortex street ($\chi = b/l$, $\mu = d/l$; l is the distance between consecutive vortexes in each row, b is the distance between the two vortex rows, d is the distance between any vortex of the first row and the next vortex of the second row; for Karman's vortex street $d = 1/2$) is investigated. It is shown that the configuration is unstable with respect to a two-group perturbation according to Schmieden.

S. D. Nigam, India

2591. Kronberg, V. A., The problem of the approximate plotting of a streamline (in Russian), *Nauch. tr. Odessk. in-ta, inzh. mor. flota* no. 11, 222–227, 1954 (1955); *Ref. Zh. Mekh.* 1956, Rev. no. 2815.

The potential of the velocities of movement of an ideal liquid caused by the forward motion of a body is represented in the form of an infinite series according to spherical functions, and the spherical function is selected in the form of a finite polynomial from fundamental functions with indeterminate coefficients. From the minimum condition of the corresponding integral in respect of the surface of the body examined, a system is set up of linear inhomogeneous equations for determining the coefficients in question. No examples of the calculation are given.

Courtesy Referativnyi Zhurnal N. A. Slezkin, USSR
Translation, courtesy Ministry of Supply, England

2592. Banerji, S. K., On the motion of iso-surfaces in a fluid medium, *Bull. Calcutta math. Soc.* **48**, 1, 1–8, Mar. 1956.

2593. Cortright, E. M., Jr., Some aerodynamic considerations of nozzle-afterbody combinations, *Aero. Engng. Rev.* **15**, 9, 59–65, Sept. 1956.

A review is made of the manner in which jet-stream interactions affect thrust and drag of various nozzle installations.

From author's summary

2594. Gault, D. E., A correlation of low-speed, airfoil-section stalling characteristics with Reynolds number and airfoil geometry, *NACA TN* 3963, 9 pp., Mar. 1957.

The low-speed stalling characteristics of a large number of airfoil sections have been correlated with Reynolds number and a single airfoil ordinate near the leading edge as the correlating parameters. The correlation is appropriate only to airfoils without high-lift devices in flows of very low turbulence and with aerodynamically smooth surfaces. From author's summary

2595. Andrews, S. J., and Schofield, N. W., An experimental investigation of a thick-aerofoil nozzle cascade, *Aero. Res. Counc. Lond. Rep. Mem.* 2883, 13 pp., 1956.

Cascade tests on a thick-airfoil turbine nozzle blade suitable for a cooled turbine show that it has a good performance over a wide incidence range up to $M = 0.8$. Above this value the loss coefficient rises and does not fall again as $M = 1$ is approached. Several methods of indication of the transition point have been tried and results show that the method depending on the evaporation of crystals gives a position inconsistent with three other methods, *i.e.*, lamp-black deposit, surface total-head measurement, and stethoscope search tube.

The effect of the thick trailing edge on loss coefficient is almost that predicted assuming zero velocity behind the blade trailing edge. The heat-transfer increase due to transition is probably not large, and is no worse than that on a conventional turbine section.

From authors' summary

2596. Alekseyev, O. I., The hydrodynamic theory of cascades of thin profiles (in Russian), *Trudi Kazansk. aviats. in-ta* no. 28, 33–48, 1953; Rev. no. 1453, *Ref. Zh. Mekh.* 1956.

An exposition is given of the solution of the problem of a fluid flow around a cascade of infinite extent, of thin, slightly curved profiles. Two kinds of such cascades are investigated: with the axis parallel to the profile chord; and with the axis perpendicular to the profile chord.

The problem is solved by displacing the vortices and sources along the profile chord. The law of distribution of the source intensities is immediately obtained in final form, while for the law of distribution of the vortex intensities, a singular, integral equation is obtained. The solution of this latter equation is referred to the Riemann boundary problem for an infinite number of contours, i.e., the Riemann problem of an open contour. The latter is solved for the case of contours having a sharp leading edge. As a result, determination of the required vortex intensity distribution is reduced to a quadratic equation.

A similar problem in a more general form has been solved by L. I. Sedov ["Plane hydrodynamic problems in aerodynamics," Gittl, 1950]. Ya. M. Kotlyar, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Compressible Flow, Gas Dynamics

(See also Revs. 2604, 2609, 2610, 2623, 2630, 2631, 2635, 2636, 2647, 2657, 2658, 2664, 2669, 2675)

2597. Hazen, D. C., Some results of the Princeton University smoke flow visualization program, Fifth International Conference, Los Angeles, Calif., June 20-23, 1955, 316-352. Inst. of the aeronautical Sciences, Inc., New York, N. Y.

Paper describes Princeton smoke tunnels and test techniques, including methods of producing smoke, design of tunnels, and lighting. A method is derived for predicting lift coefficients from observed streamline deflections measured ahead of test sections, and data presented from a sample run correlate well with this theory. A number of photographs of two- and three-dimensional smoke patterns are included to demonstrate potentialities of smoke-visualization techniques in flow study.

While much work remains to be done in this field (as author points out), reviewer feels author has convincingly demonstrated fruitfulness of smoke techniques in analyzing low-velocity flow problems. R. L. Mela, USA

2598. Matunobu, Y., Application of the thin-wing-expansion method to the compressible flow past an elliptic cylinder, with special reference to its fourth approximation, *J. phys. Soc. Japan* **12,** 1, 72-84, Jan. 1957.

Author calculates fourth-order approximation to compressible flow past elliptic cylinder using (a) transonic thin-wing-expansion method (due to Imai) and (b) complete thin-wing-expansion method (due to Hasimoto). The first method is a particular case of the second one, i. e., some simplifications are introduced due to the fact that $M \approx 1$. In both methods expansions are either in powers of thickness ratio t or of coefficient σ, which is a combination of t and M. Very tedious calculations show that results due to (a) well approximate those due to (b) provided that σ - terms are used, and that the results obtained from t - expansion seem inadequate in the fourth approximation. At any rate, neither of these results enables one to obtain the flow pattern near stagnation point, since the assumption of small perturbation fails there even before sonic speed is reached. Around this point quite a different approach must be used. The method (a) is elaborated in detail; from (b) only final results are summarized.

M. Z. Krzywoblocki, USA

2599. Mueller, J. N., and Czarnecki, K. R., Preliminary data at a Mach number of 2.40 of the characteristics of flap-type controls equipped with plain overhang balances, *NACA TN* 3948, 43 pp., Mar. 1957.

2600. Lane, F., Supersonic flow past an oscillating cascade with supersonic leading-edge locus, *J. aero. Sci.* **24,** 1, 65-66 (Readers' Forum), Jan. 1957.

2601. Lees, L., Hypersonic flow, Fifth International Conference, Los Angeles, Calif., June 20-23, 1955, 241-276. Inst. of aeronautical Sciences, Inc., New York, N. Y.

Paper gives present status of hypersonic research under the following headings: (1) Introduction and general survey. (2) Hypersonic approximations for planar bodies and slender bodies of revolution; Tangent-wedge and tangent-cone approximations, Newtonian approximation, Shock-expansion method. (3) Hypersonic viscous flow over slender bodies; Fluid mechanical models, Strong and weak interactions. Comparison between theory and experiment: influence of the leading edge at hypersonic speeds. (4) Hypersonic flow over blunt bodies; inviscid flow, heat transfer over blunt bodies.

Paper is excellent briefing on hypersonic flow problems and can be recommended to every aeronautical engineer who wishes to improve his knowledge in the field. A comprehensive bibliography of 67 papers makes the paper valuable even for those who need more basic information for the understanding.

H. J. Ramm, USA

2602. Moeckel, W. E., Oblique-shock relations at hypersonic speeds for air in chemical equilibrium, *NACA TN* 3895, 18 pp., Jan. 1957.

Oblique-shock relations for air in chemical equilibrium have been calculated for flight velocities up to 25,000 fps at altitudes up to 200,000 ft. The variation of flow-deflection angle with shock angle differs significantly from that of an ideal gas. At an altitude of 100,000 ft and a flight speed of 25,000 fps, for example, the wedge detachment angle is about 14° larger than that obtained for an ideal gas.

From the author's summary by J. Lukasiewicz, Canada

2603. Penland, J. A., Aerodynamic characteristics of a circular cylinder at Mach number 6.86 and angles of attack up to 90°, *NACA TN* 3861, 32 pp., Jan. 1957.

Pressure distributions, lift, and drag are given for angles of attack from 15° to 90°. Results are analyzed by Grimminger's hypersonic approximation [*J. aero Sci.* **17,** 11, 675 - 690, Nov. 1950], and cross-flow theory. All these theories give zero pressure coefficient at 90° from the stagnation point for unyawed cylinder, whereas present tests indicate a value of 120°. Experimental data on the stagnation pressure is in excellent agreement with the $\sin^2\alpha$ rule at angles of attack above 15°.

Fair agreement was obtained between the theoretical and experimental values of lift and drag. End effects were investigated and were found to be negligible for all tests except those at 15° angle of attack.

The pressure and drag were also plotted against the cross-flow Mach number; good agreement was found with similar results at lower supersonic Mach numbers. Author concludes that the drag coefficient of a cylinder normal to the flow remains relatively constant for Mach numbers above 4 and can be adequately predicted by the modified theoretical methods mentioned earlier.

A. W. Babister, Scotland

Wave Motion in Fluids

(See Revs. 2444, 2577, 2666, 2703, 2718, 2719)

Turbulence, Boundary Layer, etc.

(See also Revs. 2413, 2722, 2731)

2604. Moore, F. K., and Ostrach, S., Displacement thickness of the unsteady boundary layer, *J. aero. Sci.* **24,** 1, 77-78 (Readers' Forum), Jan. 1957.

The general surface condition at the surface of an impermeable solid and the equation of continuity are used to derive a defining differential equation for the displacement surface of a three-dimensional unsteady boundary layer. The result includes the usual definition of the displacement thickness of a two-dimensional boundary layer and a previous result for a three-dimensional steady boundary layer [AMR **6,** Rev. 205] as special cases. Applications are made to the case of a doubly-infinite flat plate suddenly set in motion at a high Mach number, and to the case of a compressible laminar boundary layer of a semi-infinite insulated or isothermal flat plate in nearly quasi-steady flow. L. Landweber, USA

2605. Cheng, S. -I., Some aspects of unsteady laminar boundary layer flows, *Quart. appl. Math.* **14,** 4, 337-352, Jan. 1957.

Unsteady laminar boundary-layer flow over a semi-infinite flate plate is analyzed using two methods of approach. First method

is based on the perturbation of the Rayleigh-type solution which can be regarded as a solution valid at large distances downstream of the leading edge at any time t or as a solution valid for all downstream positions during the initial period. Several difficulties are met and author concludes that it can be imagined physically that, in general, this method is not a permissable process for determining the upstream solution based upon the boundary-layer equation.

Second method assumes a uniform flow just upstream of the leading edge, and imposes the condition that the velocity component parallel to the plate immediately downstream obtained from the boundary-layer equations must pass into the uniform value on approaching the leading edge. A self-consistent approximate solution is obtained which can be continued as far downstream as desired. This solution exhibits proper downstream behavior, and also approximates to the Rayleigh-type solution for small values of t over the entire plate except near to the leading edge.

G. Power, England

2606. Delleur, J. W., The boundary layer development in open channels, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 1 *(J. Engng. Mech. Div.)* Pap. 1138, 24 pp., Jan. 1957.

Development of turbulent boundary layer is analyzed theoretically for steady flow in an open channel. Problem is solved for rectangular cross section and compared with experiment. Development is useful in predicting distance required to establish uniform flow in intake sections and in computation of theoretical discharge coefficients for broad-crested weirs. Author develops equations of boundary-layer growth by application of Bernoulli's theorem of energy, von Karman's equation of momentum for two-dimensional flow in laminar boundary layers, and Blasius' formula for friction coefficient in turbulent flow. Velocity distributions are assumed to vary according to the 1/7-th power law. Properties of boundary-layer development are analyzed in terms of two-dimensional theory; effects of sides and corners appear as corrections. Theory is tested in horizontal open channel 15 ft 7½-in. long, 13 11/16-in. wide. Velocities are measured with sensitive pitot tube and micromanometer, depths with precise point gages.

Average displacement thickness is found to agree with theory. Shape of boundary-layer development curve is confirmed, including existence of maximum thickness followed by decrease in flow close to critical; thickness equals depth in tranquil flow.

Reviewer believes this paper represents a carefully thought out approach to problem of boundary-layer development. Scattering of experimental data seems to indicate that in narrow channels secondary motions created by sidewall effects may have marked bearing on relations between theory and experiment.

M. C. Boyer, USA

2607. Delleur, J. W., The boundary layer development on a broad crested weir, Proc. fourth Midwestern Conf. fluid Mech., Purdue Univ., Sept. 1955. 183–193.

Author performs an analysis of the influence of the turbulent boundary layer on the discharge coefficient for a broad-crested weir. From author's summary by K. Sundquist, Sweden

2608. Szablewski, W., Velocity distribution close to the wall in boundary-layer flow with pressure increase (in German), *Ing.-Arch.* **23,** 4, 295-306, 1955.

The mean equations of motion for turbulent flow near a wall in the presence of a pressure gradient have been integrated to find the mean velocity distribution (law of the wall) using the Prandtl mixing-length approximation for the turbulent shear stress. The constants in the mean velocity formula are assumed to be equal to universal constants given by the empirical constants in the zero pressure gradient case. Comparison with results of Nikuradse's experiment for plane diffusers shows fair agreement, including the diffuser angle for separation, which was found by extrapolating the wall shear stress to zero. Comparison with more recent experimental results is not given.

G. M. Lilley, England

2609. Yasuhara, M., On the asymptotic solution of the laminar compressible boundary layer over a circular cylinder with uniform suction, *Rep. Inst. Sci. Technol. Tokyo* **10,** 10, 131–143, 1956.

An exact treatment of laminar compressible boundary-layer flow over a circular cylinder with uniform suction is presented for the special case when the flow condition is unchanged in the axial direction. A logarithmic term with respect to the radial distance appears in the expression of the velocity distribution, which makes, for a fixed suction intensity, the axial symmetric boundary layer thicker than the two-dimensional one. Some numerical examples are shown.

Author's treatment is the same as that given independently by H. G. Lew [*J. aero. Sci.* **23,** 9, 895-897, Sept. 1956.]

R. Kawamura, Japan

2610. Diaconis, N. S., Jack, J. R., and Wisniewski, R. J., Boundary-layer transition at Mach 3.12 as effected by cooling and nose blunting, *NACA TN* 3928, 17 pp., Jan. 1957.

An investigation was made to determine the combined effects of nose blunting and cooling on boundary-layer transition. Data are presented for both sharp and blunted cone-cylinder and parabolic-nosed-cylinder bodies at Reynolds numbers per foot up to 8×10^6.

Blunting the cone-cylinder model to a nose diameter of 3/16 inch (0.107 of maximum body diam) increased the transition Reynolds number over that obtained on the sharp model. The delay in transition with surface cooling was greater than that at equilibrium and is attributed to the increased stability of the boundary layer with cooling. These results at the lower temperature levels approached values predicted previously by theory. Blunting the nose of the parabolic-cylinder model to a 3/16-inch diameter (0.107 of body diam) produced no increase in transition Reynolds number over that measured on the sharp-nosed model at all temperature levels.

On both the cone-cylinder and parabolic-cylinder models, moderate cooling resulted in an increase in the transition Reynolds number; extreme cooling, on the other hand, decreased the transition Reynolds number. This reversal effect indicates that the transition Reynolds number may not be increased indefinitely by cooling and that a limiting temperature ratio might exist below which the laminar boundary layer becomes less stable.

From authors' summary

2611. Dutton, R. A., The asymptotic turbulent boundary layer, *J. aero. Sci.* **23,** 12, 1127–1128 (Readers' Forum), Dec. 1956.

2612. Li, T. Y., Effects of free-stream vorticity on the behavior of a viscous boundary layer, *J. aero. Sci.* **23,** 12, 1128–1129 (Readers' Forum), Dec. 1956.

2613. Schmued, E., Progress in low drag boundary-layer control, *Aero. Engng. Rev.* **16,** 3, 34–36, Mar. 1957.

Review of experiments done in the application of boundary-layer control for drag reduction, and discussion of the resulting gain in performance for long-range airplanes.

From author's summary

2614. Sakurai, T., The shear flow along a flat plate with uniform suction, *J. aero. Sci.* **24,** 1, p. 79 (Readers' Forum), Jan. 1957.

Aerodynamics of Flight; Wind Forces

(See also Revs. 2397, 2398, 2399, 2436, 2526, 2585, 2594, 2603, 2632, 2685)

2615. Sacks, A. H., Theoretical lift due to wing incidence of slender wing-body-tail combinations at zero angle of attack, *NACA TN* 3796, 35 pp., Nov. 1956.

The essential contribution consists in the *analytical* prediction of the motion of rolled-up wing vortexes downstream from the wing trailing edge as they interact with each other and with a cylindrical afterbody at zero angle of attack. The framework of slender-body theory had previously led the author to the complex variable approach in wake problems [e.g., AMR 6, Rev. 1914] and this paper again demonstrates its power. Author concludes that, except for a short distance downstream of the wing trailing edge corresponding to the actual roll-up distance of the wing vortex sheet, the afterbody may experience a substantial negative interaction lift, which, furthermore, is nonlinear in the wing angle of attack δ_w.

When tail is added to the afterbody, the calculation of its effect on the motion of the vortexes would presumably be prohibitive (as it also is for the case of body at a nonzero angle of attack). Author then assumes [see *NACA TN* 3725 for experimental analog] that vortexes are unaffected by the tail and computes the effect of the vortexes on the tail lift. The total lift is then still more nonlinear in δ_w, even for relatively high wing-aspect ratios.

M. V. Morkovin, USA

2616. Kuhn, R. E., Investigation of effectiveness of a wing equipped with a 50-percent-chord sliding flap, a 30-percent-chord slotted flap, and a 30-percent-chord slat in deflecting propeller slipstreams downward for vertical take-off, *NACA TN* 3919, 39 pp., Jan. 1957.

2617. Hurley, D. G., Note on the forces that act near the centre and the tips of swept wings, *Aero. Res. consult. Comm. aero. Res. Lab. Melbourne, Austral. Note* 150, 12 pp. + 2 figs., Feb. 1956.

A semi-infinite (or high aspect ratio) yawed wing having symmetrical sections at zero incidence is first considered. It is shown that, in incompressible inviscid flow, a thrust force acts at the trailing wing tip and a drag force acts at the leading wing tip. For high-aspect-ratio swept wings the tips experience thrust forces and the root carries a drag force. The results may also be applied to yawed swept wings of high aspect ratio. It is required in all cases that the wings have intermediate spanwise regions in which the flow pattern is essentially independent of spanwise position.

This interesting analysis is based on the conservation of energy. It is, according to the author, more accurate than previous investigations by Kuchemann and by Neumark, which gave similar results. (Reviewer has not studied these references.)

For a related study in *supersonic* flow see section 38 of "Linearized supersonic flow" by Wallace D. Hayes, North American Aviation Report no. AL-222, June 1947.

E. W. Graham, USA

2618. Levy, S., Determination of influence coefficients, *AGARD Publications, Rep.* 41, 7 pp., Feb. 1956.

The trend toward wings of extremely low aspect ratio having delta or sweptback planforms has brought an increasing need for analysis methods that do not treat the wing as a simple beam. To meet this need there has been a development of strain energy methods primarily for sweptback wings, consistent deformation methods primarily for built-up delta wings, and differential equation methods primarily for solid delta wings. Each of the methods has been successfully applied to wing types other than that for which it was primarily intended. In this paper these methods are reviewed and their advantages and limitations are discussed.

From author's summary

2619. Nuzhin, S. G., On the theory of thin-wing profiles (in Russian), *Trudi' Kazansk. aviats. in-ta* **28,** 28–32, 1953; *Ref. Zh. Mekh.* 1956, Rev. no. 2738.

This paper is a variant of "The theory of thin profiles" by the same author [title source, 1937, no. 8]. Using the turbulence method and showing, as in his previous works [*Prik. Mat. Mekh.* **11,** 1947; *Trudi' Kazansk. aviats. in-ta,* no. 20, 1948], the parametric equations of the mean line of the profile in the form of a trigonometric series, author obtains the known integral equation for a thin profile. The solution of this equation, i.e. the distribution of the circulation, is expressed by the resolution coefficients of the mean-line coordinates.

Determining by the found solution the expressions for the coefficient of lift, for the coefficient of the moment relative to the leading edge and the coordinate of focus, the author shows that they coincide with the results obtained by the method of conformal representation (see the works quoted) for arbitrary profiles, if, in the latter, the thickness of the profile is made equal to zero.

Courtesy Referativnyi Zhurnal Ya. M. Kotlyar, USSR
Translation, courtesy Ministry of Supply, England

2620. Borisenko, A. I., Graphical method for plotting generalized N. E. Joukowsky profiles (in Russian), *Trudi' Khar'kovsk. aviats. in-ta* no. 15, 13–16, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2735.

On the basis of the known method for the graphical plotting of Joukowsky profiles, a graphical method is given for plotting profiles which are very close to generalized Joukowsky profiles and for finding the speed and pressure at any point on the profile.

Courtesy Referativnyi Zhurnal S. M. Gorlin, USSR
Translation, courtesy Ministry of Supply, England

2621. Jacobs, W., Interference between fuselage and low-aspect-ratio wing according to the theory of slender bodies (in German), Jahrbuch der Wissenschaftlichen Gesellschaft für Luftfahrt, 168–171; Braunschweig, Friedr. Vieweg & Sohn, 1955.

For wing-body combinations with small aspect ratio of the wing, the interference effects of the spanwise lift distribution are calculated using a method which is, in principle, that of M. Munk for slender bodies and of R. T. Jones for wings of small aspect ratio. The method implies conformal mapping of the wing-body cross section into a circle. Examples are presented for mid-wing and high-wing combinations: These show that, for equal ratio of wing span to body diameter, the total lift is smaller for the high-wing than for the mid-wing combination, whereas the contribution of the wing is greater for the high-wing combination.

H. Schlichting, Germany

2622. Coletti, D. E., Experimental investigation of the forces and moments due to sideslip of a series of triangular vertical- and horizontal-tail combinations at Mach numbers of 1.62, 1.93, and 2.41, *NACA TN* 3846, 32 pp., Mar. 1957.

An experimental investigation was made at Mach numbers of 1.62, 1.93, and 2.41 of a series of tail combinations consisting of a triangular vertical tail attached symmetrically to a triangular horizontal tail to determine the lateral force, yawing moment, and rolling moment due to sideslip. The apex angles of both the vertical- and horizontal-tail surfaces were varied systematically in order to obtain results for an appreciable range of operating conditions.

The results of the investigation indicate that, for tails having subsonic leading edges and supersonic trailing edges, the lateral-force derivative and the yawing-moment derivative are predicted satisfactorily by the method presented in *NACA TN* 3071 except when the leading edges approach a sonic condition. The theoreti-

cal rolling-moment derivative is in fair agreement with the experimental derivative. For the limited tests in which both the leading and trailing edges were supersonic, the prediction of the lateral-force derivative and the yawing-moment derivative obtained from *NACA TN* 2412 are in good agreement with the experimental derivatives, whereas the prediction of the rolling-moment derivative is fair. From author's summary

2623. Truckenbrodt, E., Airfoil aerodynamics from point of view of the airplane manufacturers (in German), Jahrbuch der Wissenschaftlichen Gesellschaft für Luftfahrt, 143–151; Braunschweig, Friedr. Vieweg & Sohn, 1955.

The main purpose of this paper is the familiarization of German aeronautical engineers in the re-established aircraft industry with the wing developments of the last decade. A brief but well-arranged summary of major basic sweptback and delta wing configurations is offered with review of their characteristics for subsonic to supersonic flow. The theoretical reasoning, thoroughly correlated with experimental data, invites the choice of suitable wing design for a desired type of aircraft, without wind-tunnel test requirements. A full utilization and organization of all available data is motivated by the usual concern for economy, and by the fact that Germany will not have for some time any sizable wind-tunnel installations. C. R. Bell, USA

Book—2624. Pyschnow, W. S., Dynamics of flight. Influence of small disturbances [Dynamik des Fluges. Einfluss kleiner Storungen (translated from Russian), Berlin, VEB Verlag Technik, 1955, 191 pp.

This small book contains essentially an elementary treatise on low-speed longitudinal and lateral control and stability, with least possible admixture of aerodynamics. General cases are approached through long considerations on restricted or simplified situations.

Notation used is not strictly systematic; analysis is not non-dimensional. Numerical data are of general validity; references, problems and examples fail entirely.

J. W. Greidanus, Holland

2625. Pinsker, W. J. G., Comments on "Analysis of a rolling pull-out maneuver," *J. aero. Sci.* **24,** 1, 68–69 (Readers' Forum), Jan. 1957.

2626. Lovell, P. M., Jr., and Parlett, L. P., Effects of wing position and vertical-tail configuration on stability and control characteristics of a jet-powered delta-wing vertically rising airplane model, *NACA TN* 3899, 35 pp., Jan. 1957.

An investigation has been conducted to determine the effects of wing position and vertical-tail configuration on the stability and control characteristics of a jet-powered delta-wing vertically rising airplane model. A ducted-fan powerplant was used because there was no hot-jet powerplant of sufficiently small size and adequate reliability available. In addition to conventional flap-type control surfaces on the wings and vertical tails, the model had jet-reaction controls provided by movable eyelids at the rear of the tail pipe and by air bled from the main duct and exhausted through movable nozzles near the wing tips. The investigation consisted of flight and force tests of three model configurations: a high wing with a top-mounted vertical tail, a high wing with top- and bottom-mounted vertical tails, and a low wing with a top-mounted vertical tail. The flight tests, which were made in the Langley full-scale tunnel, represented slow constant-altitude transitions from hovering to normal unstalled forward flight.

From authors' summary

2627. Williams, J., and Alexander, A. J,. Some exploratory three-dimensional jet-flap experiments, *Aero. Quart.* **8,** 1, 21–30, Feb. 1957.

Paper describes a first attempt to establish the order of magnitude of finite aspect ratio effects for jet-flap wings. Lift, pitching moment, and drag results are presented from pressure-plotting measurements on a jet-flap model of aspect ratio slightly less than three. These experiments were complementary to two-dimensional tests carried out at the National Gas Turbine Establishment.

From authors' summary

2628. Hall, Sir Arnold, Some comments on current aviation topics, *J. aero Sci.* **24,** 3, 161–187, 202, Mar. 1957.

The lecture falls into two parts. The first contains comments on administrative matters affecting the research and development process; it discusses particularly the time taken in the process, the place of scientific criticism, the weapon system concept, technical education, and the relations between industry and government.

The second part of the lecture contains comments on some current technical issues particularly affecting civil aviation. The possibilities of long-range supersonic flight, the problems of structural fatigue, and the suppression of noise are among the topics discussed. From author's summary

2629. Gessow, A., and Tapscott, R. J., Charts for estimating performance of high-performance helicopters, *NACA Rep.* 1266, 33 pp., 1956.

See AMR 8, Rev. 2474.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 2435, 2600, 2627, 2657, 2660, 2663)

2630. Ashley, H., and Zartarian, G., Piston theory—a new aerodynamic tool for the aeroelastician, *J. aero. Sci.* **23,** 12, 1109–1118, Dec. 1956.

Review is given of physical basis and limitations of linearized piston theory and nonlinear extensions to include thickness, initial angle of attack, and camber. Significant feature is that local pressure depends only on local downwash in all cases. Representative applications are given for two- and three-dimensional flutter problems, panel flutter, and indicial motions. Comparisons are made with two-dimensional supersonic strip theory with fair agreement down to Mach numbers as low as two. The destabilizing effect of thickness on certain types of flutter at high Mach number is demonstrated. Emphasis is on relative simplicity of calculations using piston theory [see also following review].

H. M. Voss, USA

2631. Landahl, M. T., Unsteady flow around thin wings at high Mach numbers, *J. aero. Sci.* **24,** 1, 33–38, Jan. 1957.

Velocity potential is expanded in series in the inverse square of the Mach number, retaining terms of second order in the perturbations. Solution proceeds by iteration, employing Van Dyke's smoothing technique and Laplace transformation in the streamwise direction. In the resulting pressure distribution, the first terms represent the Hayes-Lighthill piston-theory result, while additional terms give better accuracy at lower Mach number, nonlinear effects, and some effects of three-dimensionality of the flow. Comparison indicates theory may be applicable down to Mach numbers below two for k^2M^2 small compared to one. Results permit extension of simplified flutter analysis using piston theory [see preceding review] to lower Mach number by iteration.

H. M. Voss, USA

2632. Williams, D., A simplified treatment of a fixed-root swept wing built on Hill's isoclinic principle, *Aero. Res. Counc. Lond. Rep. Mem.* 2870, 15 pp., 1956.

A swept wing using aero-isoclinic design is one that bends under lift loads about an axis parallel to flight direction. Conse-

quently there is no loss of angle of attack as compared with wing panels bending about an axis normal to the sweep line. Hill obtained this characteristic by having the flexured axis aft of the lift axis, thus compensating for loss of incidence due to bending. In the present report, author shows that reducing the torsional stiffness reduces the required gap between inertia and flexural axes, thus overcoming constructional difficulties associated with a large gap. An example is given which results in a skin thickness that is not impractical.

This note makes simplified assumptions and arrives at simple but general conclusions; that is, results are reduced to two parameters which in turn give the range of flutter and divergence. An analysis of these two parameters leads to many conclusions. For example: this wing, although immune from static divergence, is subject to dynamic divergence; however, flutter invariably intervenes before the divergence and any device that eliminates flutter does so for both. If aeroelastic troubles are by-passed, the loss of torsional stiffness is judged possibly acceptable.

R. G. Folsom, USA

2633. Gaugh, W. J., and Slap, J. K., On aeroelastic solutions, *J. aero. Sci.* **24**, 1, 76–77 (Readers' Forum), Jan. 1957.

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2410, 2411, 2457, 2652, 2654, 2656, 2743, 2744)

2634. Valdenazzi, G. L., Generalization of Euler's theory of turbomachines (in Italian), *Ingegnere* **31**, 1, 5–12, Jan. 1957.

2635. Levine, P., Two-dimensional inflow conditions for a supersonic compressor with curved blades, ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-49, 5 pp.

Paper discusses two-dimensional flow field upstream of annular cascade or rotor when undisturbed flow is supersonic relative to blades, axial flow is subsonic. Analytical method is derived based on Prandtl-Meyer flow in entrance region. For curved suction surfaces, results show that under stated conditions flow through blade row is uniquely defined by geometry of entrance region. Design charts are given. Paper is useful extension of similar earlier study of A. Kantrowitz ["The supersonic axial-flow compressor" *NACA Rep.* 974, 1950] for straight suction surfaces.

B. W. Augenstein, USA

2636. Smith, L. H., Recovery ratio—a measure of the loss recovery potential of compressor stages, ASME Ann. Meet.. New York, N. Y., Nov. 1956. Pap. 56-A-206, 24 pp.

Upstream losses or obstructions may produce distortions in compressor inlet flows. In general, the compressor stage will have an equalizing effect so outlet flow will have smaller magnitude distortions than the inlet. Using several simplifying assumptions that appear reasonably valid for a radial distortion, a "recovery ratio" is formulated in terms of familiar stage parameters to provide a type of quantitative measure of ability of stage blading to reduce the radial (axisymmetric) distortions. Results of calculations for several rotor designs at low inlet Mach number and hub/tip ratio of 0.80 show that the flow coefficient (*meridional velocity/blade speed*) should have a value near 0.5 or less for an optimum recovery and that the stage loading should be light. Expressions for compressible and incompressible flow are considered.

R. G. Folsom, USA

2637. Ikui, T., Axial-flow fans and compressors of solid vortex blading, *Mem. Fac. Engng. Kyushu Univ.* **16**, 1, 29–47, Nov. 1956.

Based on the theory of solid vortex blading, author designed and tested a two-stage axial flow fan. The results are, to a certain degree, satisfactory with increased pressure rise, reasonable efficiency, and less noise, compared with the fan of free vortex blading of the same diameter and speed.

M. Sanuki, Japan

2638. Westphal, W. R., and Godwin, W. R., Comparison of NACA 65-series compressor-blade pressure distributions and performance in a rotor and in cascade, *NACA TN* 3806, 53 pp., Mar. 1957.

An investigation has been conducted to compare the performance of NACA 65-series compressor blades in two-dimensional cascade with that in an axial-flow compressor. The entering and leaving flow velocities, pressure rise, and the pressure distribution on the rotating blades were measured at three radial stations of a free-vortex rotor. The blade pressure distributions were obtained by the use of a mercury-seal pressure-transfer device. The data obtained were compared with similar data for the same blade sections obtained from a two-dimensional porous-wall cascade tunnel.

The comparison indicated that cascade data accurately predicted the turning angle and blade pressure distribution obtained in the compressor at design conditions. At other than design angle of attack, large differences, probably due to secondary flows, were observed near the inner casing. From authors' summary

2639. Felix, A. R., Summary of 65-series compressor-blade low-speed cascade data by use of the carpet-plotting technique, *NACA TN* 3913, 9 pp., Feb. 1957.

The carpet-plotting technique is presented herein as a more useful and concise method of summarizing the NACA 65-series compressor-blade cascade data given in *NACA TN* 3916. Four different carpet plots are presented. Two of these plots facilitate the selection of blade camber and design angle of attack required to fulfill a design vector diagram. Since off-design compressor considerations are often as important as those of design, the third carpet plot facilitates the prediction of off-design turning angles at constant blade settings, despite the fact that the cascade tests were made at constant inlet-air angles with the blade settings varied. The fourth carpet plot presents an isentropic pressure-rise coefficient as a function of inlet-air angle, turning angle, and entering Mach number to permit a rapid estimation of blade loading for various velocity diagrams. From author's summary

2640. Felix, A. R., and Emery, J. C., A comparison of typical National Gas Turbine Establishment and NACA axial-flow compressor blade sections in cascade at low speed, *NACA TN* 3937, 46 pp., Mar. 1957.

2641. Seleznev, K. P., and Podobuev, Yu. S., Certain particular cases of three-dimensional flow in the stage of an axial turbomachine (in Russian), *Trudi Leningr. politekn. in-ta* no. 177, 113-122, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2780.

Certain cases of plotting the three-dimensional flow in the stage of an axial turbine and of a compressor are examined on condition that radial equilibrium is observed in the axial spaces. Flow is examined having a constant angle α_1 with respect to the radius, flow with a constant reaction with respect to the radius, and, in more detail, flow with constant circulation.

For the case of flow with a constant circulation a numerical example is given of the calculation of three-dimensional flow in a turbine stage. The results obtained are compared with the solutions which are found in the relevant literature.

Courtesy Referativnyi Zhurnal Ya. G. Shapiro, USSR
Translation, courtesy Ministry of Supply, England

2642. Zviagintsev, V. V., Increasing the efficiency of turbines by improving cascade profiles (in Russian), *Teploenergetika* **2**, 12, 3–8, Dec. 1955.

Article deals with effects of refinements in profiles of guide vanes and buckets on thermal efficiency of steam turbines. Simple

theoretical analysis of profile (velocity) losses based on average known or assumed angles and efficiencies is given in support of author's thesis that their effect is small. This, incidentally, was stated by Stodola. Some experimental data on tests carried out on single-stage impulse turbines are given. The main object of article appears to be in support of standardization of blade forms, and direction of research toward elimination of end losses.

J. J. Dziewonski, England

2643. Kulik, V. I., The influence of roughness on profile energy losses in turbine blading (in Russian), *Trudi Leningr. politekhn. in-ta* no. 177, 77–82, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2770.

Results are given of the experimental investigation of the influence of the roughness of turbine blades on profile losses. The experiment was performed on a jet engine cascade at $M = 0.2$—0.3 and at Reynolds numbers of $R = 2 \times 10^5$—3×10^5. The varying roughness was created by gluing grains of sand which had been sifted through different sieves to the surface of the blades.

Three types of surfaces were tested with a mean height of protuberance of 50, 130, and 220 μ, which were compared with a polished blade. The reduction in efficiency was 1.6%, 4.8%, and 6.3%.

In the second group of tests the individual influence of the roughness on concave and convex surfaces was investigated. It was found that the roughness on the convex side has almost twice as much influence on the efficiency as that on the concave side. At the same time, a reduction in the height of the proturbances to a dimension of < 20 μ for the convex side and of < 50 μ for the concave side becomes almost inappreciable in practice. On this basis, author recommends fitting the turbines with cast blades without mechanical finishing.

In the third group of tests the influence on the losses of local increase of roughness was investigated.

Courtesy Referativnyi Zhurnal Ya. G. Shapiro, USSR
Translation, courtesy Ministry of Supply, England

2644. Abe, S., On the theory of windmills, *Sci. Rep. Res. Inst. Tohoku Univ. Japan (B)* **7**, 135–148, 1956.

Theory considers the following effects: (1) number of blades; (2) cascade interference; (3) induced velocities; (4) starting characteristics. The selection of the distribution of circulation for maximum power is presented. Theory agrees well with model test data. H. P. Liepman, USA

2645. Zavadovskii, A. M., Calculation of free-piston gas generators for gas-turbine installations (in Russian), *Teploenergetika* **3**, 1, 29–35, Jan. 1956.

Flow and Flight Test Techniques

(See also Revs. 2479, 2597, 2627)

2646. Togino, K., and Shimoda, Y., Electromagnetic flowmeter, *J. mech. Lab. Tokyo* **2**, 1, 15–19, 1956.

2647. Furuya, Y., and Suzuki, K., Experiments on the efficiency of conical diffuser; initial state of flow separation (in Japanese), *Trans. Japan Soc. mech. Engrs.* **25**, 125, 7–13, Jan. 1957.

Measurements were made on the flow in a 20° conical diffuser in which separation of flow took place near the wall. Position of separation was found to agree well with that predicted by boundary-layer calculation. Correlation measurements by hot-wire anemometer revealed the asymmetric oscillation of the separated flow.

I. Tani, Japan

2648. Miroux, J., The potentialities of an analog apparatus for measuring gradients and for tracing fields of equal speeds directly (in French), *ONERA* no. 53, 53–57, Sept./Oct. 1956.

Author describes application of a double-probe electrolytic tank technique for rapid determination of lines of equal velocity about complicated two-dimensional profiles. Without giving too much detail, author describes the use of servomechanisms as means for making rapid surveys; that is, the double probe is led to seek lines of equal potential gradients whose values are preset by an external circuit. Examples of typical application of the technique are given. M. S. Macovsky, USA

2649. Girard, A., and Robert, E., Stereoscopic chronophotography of particles in suspension in aerodynamic flow (in French), *Rech. aéro.* no. 49, 31–39, 1956.

2650. Deacon, E. L., and Samuel, D. R., A linear, temperature compensated hot-wire anemometer, *J. sci. Instrum.* **34**, 1, 24–26, Jan. 1957.

A hot-wire anemometer is described which gives a linear output over the range of wind speed 1 to 16 m/s and is therefore well suited to studies of atmospheric turbulence. It is also provided with temperature compensation so that the effects of air temperature fluctuations (both rapid and slow) are eliminated. These desiderata are achieved with little increase in complexity over the simple hot-wire circuit. From authors' summary

2651. Van Der Maas, C. J., Elevated temperature requirements for a new air-borne flight analyzer, *Aero. Engng. Rev.* **16**, 3, 37–41, Mar. 1957.

The paper discusses the need for an instrument making possible the collection of operational time histories of the accelerations, static pressure, total head pressure, and stagnation temperature of high-speed aircraft. From author's summary

2652. Kurzweg, H. H., and Wilson, R. E., Experimental hyperballistics, *Aero. Engng. Rev.* **15**, 12, 32–38, Dec. 1956.

2653. Salmirs, S., and Tapscott, R. J., Instrument flight trials with a helicopter stabilized in attitude about each axis individually, *NACA TN* 3947, 17 pp., Jan. 1957.

2654. Goodman, T. R., The tip correction for wind-tunnel tests of propellers, *J. aero. Sci.* **23**, 12, 1094–1098, Dec. 1956.

A low-speed (incompressible) analysis of a lightly loaded propeller with a large number of blades is presented and expressions for the elements of thrust and torque on a blade element are obtained. (Reproduced from Glauert's article in Durand, "Aerodynamic theory.") To account for a propeller with a finite number of blades in the presence of a nearby wall, author reworks a solution by Prandtl to obtain the correction to apply to wind-tunnel data for thrust and efficiency for incompressible flow.

The effect of the walls is (1) to increase the thrust and (2) to decrease propulsive efficiency. Author presents graphs for the computation of corrections in thrust and efficiency for two-, three-, and four-bladed propellers as a function of advance ratio and ratio of propeller radius to tunnel radius. R. G. Nevins, USA

2655. D'Andrea, J. B., Automatic indicating and recording data systems for wind tunnels, *AGARD Publications, Rep.* 16, 41 pp., Feb. 1956.

2656. Fejer, A. A., and Clark, J., Compressors for high-speed wind tunnels, *AGARD Publications, Rep.* 14, 216 pp., Jan. 1956.

Paper is one of a series issued by AGARD on various aspects of wind-tunnel design and operation. Type of wind tunnel mainly considered is continuous flow closed return supersonic tunnel. Brief outline is given of aerodynamics of wind-tunnel circuit, leading up to discussion of compressor requirements, problems of matching compressor and tunnel, and choice of compressor type and system of drive. This is followed by brief survey of aero-

dynamic design principles of compressors and short discussion of associated mechanical engineering problems, including shafting, bearings, and vibrations.

Paper should be very useful to anyone starting design of wind tunnel of this type. W. A. Mair, England

2657. Runyan, H. L., Woolston, D. S., and Rainey, A. G., Theoretical and experimental investigation of the effect of tunnel walls on the forces of an oscillating airfoil in two-dimensional subsonic compressible flow, *NACA Rep.* 1262, 21 pp., 1956.

See AMR 9, Rev. 266.

2658. Maeder, P. F., and Wood, A. D., Transonic wind-tunnel test sections, *Z. angew. Phys.* **7,** 3, 177–212, 1956.

Prof. P. F. Maeder is well known in the field of transonic aerodynamics. His paper represents a concise but comprehensive study of the transonic wind tunnel. First, the methods of replacement of an inhomogeneous boundary such as slots or perforations by mean boundary conditions are shown, and complex perturbation potential is derived. The value of the work is greatly enhanced by a constant care to obtain a physical understanding of mathematical terms. Interference in subsonic region is investigated for partially open test sections, such as those having walls with longitudinal slots, perforated and porous walls, etc. The results are given in graphs, representing the blockage and incidence interference for finite wings, and two-dimensional sources and doublets. It has been shown that the blockage and buoyancy interference on the model can be eliminated by proper choice of slot configurations; the same applies to the wake interference. The elimination of interferences for perforated rectangular test section is also shown. In supersonic flow, the longitudinal slots do not produce the initial attenuation of disturbance, but the reflected waves of opposite sign reduce the interference of the model. A better attenuation is expected for three-dimensional tunnel than for the two-dimensional, except for the case of a circular section; but the perforated wall seems to perform more satisfactorily in the two-dimensional case. In general, a slotted wall test section will require more power than one with perforated walls; graphs of values of blockage interference due to the reflection of a disturbance from a slotted wall, etc., contribute to the value of the paper.

P. Bielkowicz, USA

2659. Beam, B. H., A wind-tunnel test technique for measuring the dynamic rotary stability derivatives at subsonic and supersonic speeds, *NACA Rep.* 1258, 14 pp., 1956.

See AMR 8, Rev. 2452.

2660. Clevenson, S. A., and Tomassoni, J. E., Experimental investigation of the oscillating forces and moments on a two-dimensional wing equipped with an oscillating circular-arc spoiler, *NACA TN* 3949, 20 pp., Mar. 1957.

Results are presented of an experimental investigation in the Langley 2- by 4-ft flutter research tunnel on the oscillating forces and moments on a two-dimensional wing equipped with an oscillating circular-arc spoiler. The forces and moments and their phase angles with respect to spoiler motion were determined from measurements of the instantaneous pressure distribution, and the nature of the flow over the wing was studied with schlieren photographs. Data are presented for Reynolds numbers from 1.3×10^6 to 6.3×10^6, Mach numbers from 0.20 to 0.82, and reduced frequencies from 0 to 0.92. The results of this study indicate that the force and moment coefficients and their phase angles are affected in a complex manner by Reynolds number, Mach number, and reduced frequency. From authors' summary

2661. Christopher, K. W., Investigation of the planing lift of a flat plate at speeds up to 170 feet per second, *NACA TN* 3951, 15 pp., Mar. 1957.

An experimental investigation has been made in the Langley high-speed hydrodynamics facility to determine whether the planing lift coefficient of a flat-bottom planing surface remains constant with increasing speed at the high towing speeds obtainable from this facility. Measurements were made of lift and wetted area at speeds ranging from 80 to 170 fps over a range of trims from 4° to 30° and at wetted-length/beam ratios of approximately 2 and 5.

No effect of speed on the planing lift coefficient was noted for the range of speeds tested, and the data agreed well with those recently obtained in lower-speed towing tanks. These results confirm the generally accepted assumption that positive-pressure planing lift coefficients do not vary with speed even at speeds extending to full-scale take-off speeds.

From author's summary

2662. Lovell, P. M., Jr., and Parlett, L. P., Flight tests of a model of a high-wing transport vertical-take-off airplane with tilting wing and propellers and with jet controls at the rear of the fuselage for pitch and yaw control, *NACA TN* 3912, 28 pp., Mar. 1957.

An investigation of the stability and control of a high-wing transport vertical-take-off airplane with four engines during constant-altitude transitions from hovering to normal forward flight was conducted with a remotely controlled free-flight model. The model had four propellers distributed along the wing with thrust axes in the wing chord plane, and the wing, which was pivoted at 15% mean aerodynamic chord, could be rotated to 90° incidence so that the propeller thrust axes were vertical for hovering flight. Jet-reaction controls at the rear of the fuselage provided pitch and yaw control for hovering and low-speed flight. The wing had a trailing-edge flap which was undeflected for one series of tests and deflected 30° for another series.

The model experienced a nose-up change in pitch trim at low speeds in the transition from hovering to forward flight. Because of this trim change, the most rearward center-of-gravity location at which the model could be flown was limited to 8% mean aerodynamic chord rearward of the wing pivot point with the wing flaps deflected and 6% mean aerodynamic chord rearward of the wing pivot point with the flaps undeflected. When the center of gravity was located rearward of these points, the model experienced a nose-up pitching divergence. The most forward center-of-gravity location at which the model could be flown, which was established only for the flap-deflected case, was 12% mean aerodynamic chord forward of the wing pivot point. The lateral stability and control characteristics were generally satisfactory even though the Dutch-roll oscillation was lightly damped for certain conditions of airspeed and fuselage attitude. The jet controls at the rear of the fuselage provided good pitch and yaw control throughout the entire speed range. From authors' summary

2663. Barth, R., How the form and flow around car bodies influence the resistance, road holding, and directional stability (in German), *ZVDI* **98,** 22, 1265–1275, Aug. 1956.

Results of an extensive wind-tunnel testing program on different models of car bodies are presented in numerous graphs and diagrams. Measurements on a six-component balance gave data for resistance, lift and yaw characteristics. Because all graphs are well illustrated with sketches of the forms tested it is easy to interpret the over-all picture without much knowledge of German. Both students and designers will find many useful data in this paper. M. Rand, Canada

2664. Glass, I. I., and Patterson, G. N., Contributions to fluid mechanics from shock tube research, Proceedings of the Fifth International Aeronautical Conference, Los Angeles, June 20–23, 1955, 200–240. New York, Inst. of the aeronautical Sciences, Inc.

After reviewing the simple theory of the idealized wave pattern for a shock tube, the observed deviations from the theory are dis-

cussed, especially the relaxation effects as indicated by the exponential rise in density behind the shock front. The physical properties of rarefaction waves, contact surfaces, and shock fronts are investigated using piezoelectric gage, hot-wire anemometer, and chrono-interferometer for measuring pressure, temperature, and density transition. Special attention is given to the growth of the boundary layer and its effects on performance of the shock tube. The contributions made by shock-tube research apply mainly to fluid mechanics rather than applied aerodynamics. Valuable research has been made with hypersonic test facilities and has shown the need of a new theoretical approach on molecular basis. W. Wuest, Germany

2665. Knowler, A., Shock tubes, *Research, Lond.* **10,** 4, 132–137, Apr. 1957.

The shock tube offers to the physicist and chemist temperatures of 18,000C or more and to the aerodynamicist speeds of fifteen times that of sound. The attainment of such temperature and speed is admittedly only for milliseconds but, with appropriate instruments, many measurements can be made in that time.

From author's summary

2666. Dressler, R. F., Entropy changes in rarefaction waves, *J. Res. nat. Bur. Stands.* **57,** 5, 265–271, Nov. 1956.

Author uses one-dimensional approximation for flow in ducts with wall friction to treat case of polytropic gas expanding into a vacuum. Without wall friction, flow is due to a centered complete rarefaction wave. Author derives and solves equations for first-order perturbations, due to wall friction, of fluid speed, sound speed and entropy, assuming wall-friction coefficient small and constant. All perturbation solutions become infinite on forward wave front.

Reviewer considers that gain in simplicity of wave pattern by the assumption of expansion into a vacuum is counterbalanced by a loss of engineering significance and singularity troubles on forward wave front. The singularities make assessment of region of validity of results difficult, but presumably could be avoided by abandoning the assumption, over-stringent for this case, that wall-friction coefficient is constant. H. C. Levey, Australia

Thermodynamics

(See also Revs. 2570, 2589, 2601, 2602, 2645, 2677, 2704)

2667. Simon, Sir Francis, The third law of thermodynamics—an historical survey (in German), *Kältetechnik* **9,** 3, 58–61, Mar. 1957.

Fifty years ago Nernst enunciated his so-called Heat Theorem which has now become the Third Law of Thermodynamics. At first the theorem was considered mainly as a means of predicting chemical equilibria and was only applicable to condensed systems Later on its formulation as the law of unattainability of absolute zero and its extension to gaseous systems (gas-degeneracy) led to Nernst's claim that it was a law of general validity. More investigations disclosed a number of notable discrepancies and led for a time to its rejection by many physicists. A combination of thermodynamic and statistical reasoning, however, showed that the supposed violations only happened in systems not in thermodynamic equilibrium. The formulation: "The entropy of all factors within a system which are in internal thermodynamic equilibrium disappears at absolute zero" covers all cases without exception and is, therefore, an expression of a general law of thermodynamics.

From author's summary

2668. Othmer, D. F., Maurer, P. M., Molinary, C. J., and Kowalski, R. C., Correlating vapor pressures and other physical properties, *Indust. Engng. Chem.* **49,** 1, 125–137, Jan. 1957.

2669. Fafchamps, J., Investigation of the mean enthalpy of a gas flow (in French), *Rev. univ. Min.* (9) **13,** 1, 2–32, Jan. 1957.

The determination of the mean enthalpy of a gas flow involves the knowledge of the velocity field of the mass and that of the temperature. Paper contains a detailed discussion and experimental study of the different methods and theories for determining these two velocity fields and their accuracy.

L. Meyer, USA

2670. Hirschfelder, J. O., Buehler, R. J., McGee, H. A., Jr., and Sutton, J. R., A generalized equation of state for both gases and liquids, I, *Univ. Wisc., Nav. Res. Lab., Dept. Chem. Tech. Rep.* WIS-OOR-15, 67 pp., Oct. 1956.

An equation of state for pure substances is presented which covers the full range of gases and liquids. The standard form of the equation is based on a generalized principle of corresponding states which includes two additional experimental parameters: the critical compressibility factor z_c, and a parameter α determined from the vapor pressure. The equation for liquids also includes experimental densities at saturation. Considerable flexibility exists since the equations can be used when experimental parameter values are missing, and paper shows also how the standard form can be improved when extensive data are available. Functional forms have been chosen which are suitable for high-speed digital computing machines.

The equations have been compared with existing equation-of-state data for a wide variety of substances and for wide varieties of temperatures and pressures. In a gas at a density up to the critical density, the pressure is predicted to within one or two per cent of the experimental values, and in a gas at densities higher than the critical density, the average deviations in pressure are of the order of four per cent. In the liquid region greater errors in the pressure are encountered since the pressure in the liquid phase is extraordinarily sensitive to the assumed density—an error of 0.01 in the reduced density may correspond to an error of 1.0 in the reduced pressure. On the other hand, this sensitivity allows for very accurate prediction of density when temperature and pressure are known. From authors' summary

2671. Briggs, D. K. H., Thermal conductivity of liquids, *Indust. Engng. Chem.* **49,** 3, 418–421, Mar. 1957.

A general equation for commercial tar distillate fractions useful over the temperature range 20 to 150 C.

From author's summary

2672. Kollerov, D. K., Bachinskii's viscosity law (in Russian), *Trudi Vses. n.-i in-ta po pererabotke slantsev* **2,** 216–227, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2895.

It is shown that, for variation in the viscosity of a liquid with temperature, the formula proposed by A. I. Bachinskii is well confirmed by experiment

$$\eta_t = \frac{c}{V_t - \omega}$$

where η_t is the absolute viscosity at the temperature t (in poise), c is the constant characteristic for the given substance, V_t is the specific volume at the same temperature, ω is any constant similar to the value b of the Van der Waals' equation. For extension of Bachinskii's formula to a wide class of liquids and for facilitating its use in calculation, certain relations are suggested for the values indicated.

Courtesy Referativnyi Zhurnal A. I. Golubev, USSR
Translation, courtesy Ministry of Supply, England

2673. Barger, J. P., Rohsenow, W. M., and Treadwell, K. M., Turboconditioning systems with vapor compression cycles, ASME Semiann. Meet., Cleveland, O., June 1956. Pap. 6-SA-7, 12 pp. + 35 figs.

2674. Zaitsev, Yu. I., A method of thermal calculation of steam and gas turbines according to aerodynamic characteristics (in Russian), *Trudi Leningr. korablestroit. in-ta* no. 15, 121–135, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2782.

A method is given for the thermal calculation of a jet turbine according to the aerodynamic characteristics of the profile cascades. In order to perform the calculation it is necessary to use the data of flow through two-dimensional cascades which are found in the appropriate literature. The aerodynamic characteristics of certain profiles are given.

Courtesy Referativnyi Zhurnal Ya. G. Shapiro, USSR
Translation, courtesy Ministry of Supply, England

2675. Kerimov, I. G., Rozlovsky, A. I., and Shaulov, Yu. Kh., On the determination of thermodynamic characteristics by the method of measuring the explosion pressure in an enclosed space (in Russian), *Trudi in-ta fiziki i matem. Az SSR, ser. fiz.* no. 7, 41–49, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 1355.

From the measured temperature of explosion, the heat content of water vapor at combustion temperature and the heat effect of the dissociation of water into hydroxyl and hydrogen are calculated. The calculations have been made by solving the equation of the material balance and chemical equilibrium. The initial thermodynamic data are taken from the works of B. Lewis and G. Elbe ["Combustion, flame and explosion in gases," 1938–1948], and the monograph of Ya. B. Zeldovich and A. I. Polyarny [Calculation of heat processes at high temperatures, 1947].

The heat contents calculated from the explosion pressure of water vapor and the thermal effect of the dissociation of water into hydrogen and hydroxyl differ but little from the values given by Lewis and Elbe. S. M. Il'yashenko, USSR
Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Heat and Mass Transfer

(See also Revs. 2441, 2451, 2452, 2485, 2524, 2561, 2650, 2671, 2673, 2728)

2676. Madan, Mahendra P., Simple bridge method for the measurement of thermal conductivity of gases and gas mixtures, *J. Franklin Inst.* **263**, 3, 207–212, Mar. 1957.

Paper describes measurement of conductivity of gases at low pressure, utilizing change of electric resistance of a thin wire heated by electric current and placed in a cylinder filled with that gas. Formulas for evaluation and for corrections are developed.

No quantitative values of accuracy are given.

L. S. Dzung, Switzerland

2677. Rottenburg, P. A., Heat transfer media for use at elevated temperatures, *Trans. Inst. chem. Engrs.* **35**, 1, 21–36, 1957.

The properties necessary for materials to be suitable as heat-transfer media are discussed. Possible fluids are reviewed in the light of these criteria. The commercially available media are surveyed and their important physical properties tabulated.

From author's summary

2678. Vidal, J., Study of thermal fields by electrical analogies (in French), *Rev. univ. Min. (9)* **13**, 9, 32–50, Jan. 1957.

2679. Selig, F., and Fieber, H., Heat conduction problems with time-variable surface-transfer coefficient (in German), *Öst. Ing.-Arch.* **11**, 1, 37–40, 1957.

Authors propose change of variables to transform heat-conduction problem with specified time-dependent transfer at fixed boundary into problem with constant transfer at moving boundary. Differential equation is stated to be invariant. This is true in the special cases cited, but reviewer feels further justification is needed for more general claims. S. Paterson, Scotland

2680. Korobkin, I., and Gruenewald, K. H., Investigation of local laminar heat transfer on a hemisphere for supersonic Mach numbers at low rates of heat flux, *J. aero. Sci.* **24**, 3, 188–194, Mar. 1957.

Measurements of pressure and local heat-transfer characteristics for a hemispherical nose with laminar boundary-layer flow are reported with a description of the procedures. These measurements are of considerable interest because of the use of radomes on high-speed vehicles. Tests were conducted on a 2-in. hemispherical nose in an aeroballistics tunnel with atmospheric supply conditions. Pressure and heat-transfer measurements were made for Mach number ranges of 0.26 to 4.87 and 1.90 to 4.87, respectively. Heat-transfer coefficients were defined in terms of "effective" temperature rather than the adiabatic wall temperature.

The experimental results show that a single curve derived from incompressible theory and the true velocity distributions along the surface represents nondimensional coefficients; Mach number dependency in the investigated range can be eliminated by expressing the local velocity distribution along the spherical surface by the nondimensional parameter $U/\beta D$. Although the "effective" temperature and the adiabatic wall temperature differ by more than 5%, this distinction need not be made by the designer of high-speed vehicles subject to high rates of heat transfer. Furthermore, it was shown that the local heat-transfer coefficient is independent of temperature.

The results obtained in this paper represent a valuable contribution in extending the earlier works of Stolder and Melsen [*NACA TN* 3287, 1954], Stine and Wanlass [AMR **8**, Rev. 2527], Falkner and Skan [*Phil. Mag.* **12**, p. 865, 1931], and Drake [AMR **6**, Rev. 3817]. J. F. Lee, USA

2681. Lewis, J. P., and Ruggeri, R. S., Investigation of heat transfer from a stationary and rotating ellipsoidal forebody of fineness ratio 3, *NACA TN* 3837, 46 pp., Nov. 1956.

Paper describes investigation of convective heat transfer from the surface of an ellipsoidal forebody, for various air speeds, rotational speeds, and angles of attack. Results are presented in form of heat-transfer coefficients and correlation of Nusselt and Reynolds numbers. Both uniform surface temperature and uniform input heater density distribution were used.

Experimental results agree well with theoretical predictions for uniform surface temperature, but complete agreement was not obtained with uniform input heat density in the laminar flow region due to conduction effects. Angles of attack had only minor effects on the local heat transfer, while no significant effects were observed due to rotation over the range of speeds investigated.

From authors' summary by A. F. W. Langford, Australia

2682. Mahony, J. J., Heat transfer at small Grashof numbers, *Proc. roy. Soc. Lond. (A)* **238**, 1214, 412–423, Jan. 1957.

A mathematical analysis is made of heat loss from the following shapes immersed in a fluid: a sphere, an infinite and a finite horizontal wire. The experimentally established fact that for very small Grashof numbers G heat transfer from a body cannot be calculated from the heat-conduction equation alone is justified by this analysis. It is shown that although convection is negligible near the body, it becomes significant beyond distances from the body of the order, for a sphere, of $G^{-1/2}$ times its radius, and, for a cylinder, $G^{-1/3}$ times its radius. Only when this distance is large compared to the radius of the body is the pure conduction equation applicable in calculating heat-transfer rates.

In a plot of the reciprocal of the Nusselt number versus $\log_{10} G$ the results of the analyses for an infinite and a finite cylinder are compared with experimental data for a finite cylinder.

D. M. Mason, USA

2683. Prokofiev, V. A., On the influence of radiation in the monodimensional motion of a monatomic gas (in Russian), *Ucb. zap. Mosk. un-ta* **172**, 5, 79–124, 1954; *Ref. Zb. Mekb.* 1956, Rev. no. 1347.

The introduction lays down the fundamental conceptions of astrophysics on the interaction between radiation and medium; the fundamental equations of motion of the medium, corrected for the effect of radiation, are derived; and the fundamental principles of quantum thermodynamics are stated, enabling calculation of the energy of the perturbed atoms (allowance for dissociation and ionization). Further, monodimensional steady motion of a perfect gas is examined in relation to the inflow of heat due to radiation (without consideration of viscosity and heat conductivity). Investigation of the structure of the density jump leads the author to conclude that the structure of the density (compression) shock in the particular case will depend on the quantity of energy of radiation (i.e. temperature); in particular, the gradients of the pressure and velocity within the jump are distributed differently from the ordinary case, while the thickness of the jump (region) does not, practically, change, remaining of the order of magnitude of the mean-free-path length of the gas. The "optical thickness" of the jump is found to be of the order of magnitude of the free path of the radiation. K. P. Stanyukovich, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2684. Gurvich, A. M., and Mitor, V. V., Radiation of flue gases (in Russian), *Teploenergetika* **2**, 12, 28–31, Dec. 1955.

2685. Teteryukov, A., Flight in icing conditions (in Russian), *Grazhdanskaya aviatsiya* no. 2, 12–15, 1955; *Ref. Zb. Mekb.* 1956, Rev. no. 1398.

An analysis is presented of the influence of icing of an airplane and parts thereof on its aerodynamic characteristics. Detailed results are quoted of experimental investigations made principally on an Ilyushin 12 aircraft in conditions of heavy icing, as well as a comparison of the aerodynamic characteristics in different icing conditions, and an analysis of the change in flying behavior, stability, and controlability. Recommendations are made of an operational and technical character for the piloting of aircraft in different icing conditions.

Photographs are reproduced of ice formation on parts of aircraft, and diagrams of the change in aerodynamic characteristics and behavior in flight, of an Ilyushin 12 aircraft in icing conditions.

Courtesy of Referativnyi Zhurnal S. M. Gorlin, USSR
Translation, courtesy Ministry of Supply, England

2686. Pokhovich, A. I., Calculation of the heating power of water intake cascades (in Russian), *Izv. Vses. n.-i. in-ta gidrotekbn.* **53**, 228–240, 1955; *Ref. Zb. Mekb.* 1956, Rev. no. 2930.

The phenomenon of freezing is examined, as well as existing methods of calculating the power of heating the rods of water intake cascades. It was shown that the methods used for calculating the heating power according to the mean coefficient of heat emission are unsatisfactory. A new method for calculating the heating power and certain measures in reducing the energy expenditure on heating are suggested. V. N. Krilov, USSR

Courtesy of Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2687. Makovozov, M. I., Heat power tests of roller driers (in Russian), *Trudi Mosk. Tekbnol. in-ta myasnoi i molocbn. prom-sti.* no. 2, 79–84, 1954; *Ref. Zb. Mekb.* 1956, Rev. no. 2948.

Results are given of the experimental investigation of the contact drying of liquid materials on two roller driers with varying rpm of the cylinders. I. N. Kochina, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of supply, England

2688. Grishechko-Klimov, S. M., Calculation of the drying ventilation of windows (in Russian), *Symp. papers Vses. zaocb. politekbn. in-ta* no. 10, 94–97, 1955; *Ref. Zb. Mekb.* 1956, Rev. no. 2947.

A suggestion is made for combatting the condensation of aqueous vapor on the internal surface of external glass by means of the ventilation of the interframe space by the external air.

For this purpose the outer covers should have orifices above and below. Author gives examples of determining the amount of air penetrating into the interframe space, air temperatures in the latter on the surface of the inner and outer glass, as well as the areas of the ventilation holes which require the condensation of vapor on the inner surface of the outer glass to be obviated.

In order to prevent the freezing of the inner glass as the calculations show, it is necessary to increase the air temperature in the interframe space, which in turn leads to a reduction of the required heat exchange in the interframe space.

Courtesy Referativnyi Zhurnal S. D. Krongauz, USSR
Translation, courtesy Ministry of Supply, England

2689. Guigo, E. I., Mechanism of drying moist materials by sublimation (in Russian), *Trudi Leningrad tekbnol. in-ta Kbolodiln. prom-sti* **9**, 61–69, 1955; *Ref. Zb. Mekb.* 1956, Rev. no. 2946.

The theoretical bases of drying moist materials by means of sublimation are explained. The mechanism of drying by sublimation of all the moist materials which are of heterogeneous structure is identical in principle and very similar to the mechanism of drying by means of evaporation of capillary-porous materials in the case of heat supply by radiation. S. D. Krongauz, USSR

Courtesy Referativnyi Zhuranl
Translation, courtesy Ministry of Supply, England

2690. Kosterin, S. I., Sheinin, B. I., and Katarzhis, A. K., Experimental characteristics of the concurrent flow of a steam-water mixture in a straight horizontal tube (in Russian), *Teploenergetika* **3**, 1, 22–26, Jan. 1956.

2691. Dedusenko, Yu. M., The problem of determining the optimum exponents of counterflow heat exchangers in gas turbines (in Russian), *Symp. tr. Labor problem bystrokbod. masbin i mekbanizmov Akad. Nauk. Ukr. SSR* no. 5, 125–148, 1955; *Ref. Zb. Mekb.* 1956, Rev. no. 2929.

The problem is examined of the choice of the rational dimensions of a tubular heat exchanger for the heat regeneration of the discharge gases in a gas turbine engine. In the first part, the connection between the efficiency and the losses of pressure in the heat exchanger is established. The approximate expressions are given for the optimum degree of compression and the maximum efficiency with given parameters of the cycle and of the degree of regeneration from which it follows that, in order to obtain an advantage in the efficiency from the regeneration, the relative pressure losses should not exceed a specific value.

The second part is devoted to the description of the tubular heat exchanger working according to the counterflow arrangement.

Courtesy Referativnyi Zhurnal L. I. Kiselev, USSR
Translation, courtesy Ministry of Supply, England

Combustion

(See also Revs. 2683, 2684)

2692. Swarts, D. E., and Orchin, M., Spontaneous ignition temperature of hydrocarbons, *Indust. Engng. Chem.* **49**, 3, 432–436, Mar. 1957.

A three-dimensional diagram illustrates the dependence of spontaneous ignition temperatures on surface-volume ratio of the apparatus and the effect of pressure.

From authors' summary

2693. Rappeneau, J., Investigation of the combustion of a hydrocarbon mixture (in French), *Publ. sci. tech. Min. Air, France* no. 318, 90 pp., 1956.

2694. Ordin, P. M., Hydrogen-oxygen explosions in exhaust ducting, *NACA TN* 3935, 31 pp., Apr. 1957.

The ignition of hydrogen-oxygen gas mixtures at a pressure of 1 atm in a 2-ft-diam duct resulted in detonation combustion. The detonation static pressure at an oxidant-fuel mole ratio of 0.82 was about 315 lb/sq in. abs (pressure-rise ratio of 21). The use of water curtain sprays distributed through a substantial section of the duct did not prevent a detonation but did reduce the peak pressure to 200 lb/sq in. abs. The detonation could be prevented by adding sufficient carbon dioxide to place the gas mixture out of the flammable range. The use of smaller quantities of carbon dioxide resulted in a reduction in the peak detonation pressures. The total pressures exerted on various designs of 90° steel elbows by the detonation were about 900 lb/sq in. abs (pressure-rise ratio of 60). A design stress of 38,400 psi and suitable supporting members for the exhaust duct elbow contained the detonation without any damage to the structure.

From author's summary

2695. Mason, D. M., Properties of fuming nitric acid affecting its storage and use as a rocket propellant, *Jet Propulsion* **26**, 9, 741–745, Sept. 1956.

2696. Zastela, Yu. K., The coefficient of useful action of the combustion chamber of a gas turbine engine (in Russian), *Trudi Kazansk. aviats. in-ta* **29**, 123–138, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2785.

Expressions are derived for the thermal, hydraulic, and general efficiency of combustion chambers which is the product of the first two efficiencies and which has regard to all forms of loss of energy in the chamber. The individual influence of the combustion chamber, of the coefficient of excess air, of the degree of pressure increase, of the coefficient of pressure, of the coefficient of thermal liberation, of the temperature at entry to and exit from the chamber; all are examined for their effect upon the efficiency.

Courtesy Referativnyi Zhurnal M. A. Peshkin, USSR
Translation, courtesy Ministry of Supply, England

2697. Gruwer, J., Singer, J. M., Richmond, J. H., Oxendine, J. R., Photographic studies of turbulent flame structure, *Indust. Engng. Chem.* **49**, 2, 305–312, Feb. 1957.

Experiments showed that the turbulent flame brush is a zone of nonhomogeneous and partly discontinuous burning. Flamelets within the brush are extinguished by turbulent mixing of burned and unburned gas, ignited by turbulent transport of enthalpy into transient zones of ignitable gas. Ignition depends significantly on chemical considerations affecting ignition lag and ignition temperature.

From authors' summary

2698. Sanger, E., Steady nuclear combustion in rockets, *NACA TM* 1405, 39 pp., Apr. 1957.

Astrophysical theory is applied to study possibilities for thermonuclear reactions to be used as an energy source for the propulsion of atomic rockets, photon rockets, turbojets, and ram jets. Results indicate maximum heat production at 10^8 °K for the hydrogen isotopes. For chamber pressures of 100 atm the energy release 10^4 kcal/(cu m)(sec) is comparable to that of the chemical fuels. The effect of burnup time and of the degree of complete ionization on the balance between energy release and energy radiated is determined.

From author's summary

Acoustics

(See also Revs. 2373, 2427, 2430, 2571, 2723)

2699. Etkin, B., Korbacher, G. K., and Keefe, R. T., Acoustic radiation from a stationary cylinder in a fluid stream (aeolian tones), *J. acoust. Soc. Amer.* **29**, 1, 30–36, Jan. 1957.

A cylindrical obstacle located at right angles to the direction of flow of a fluid produces a wake in the form of regularly spaced vortexes of alternatingly clockwise and counterclockwise orientation. This phenomenon has long been familiar to mechanical engineers, as it gives rise to "galloping" of transmission lines and pipelines, and swaying of smokestacks. The associated sound, in the form of aeolian tones, has been repeatedly studied by acousticians. Authors of this paper derive expressions for sound field in terms of lift and drag coefficients. The assumption that the cylinder is motionless detracts little from the validity of the analysis, as the sound is predominantly aerodynamic. Good qualitative agreement between theory and experiments in subsonic wind tunnel was obtained. Main results are that the fundamental tone, apparently associated with the oscillatory lift forces, radiates most strongly at right angles to the stream; the harmonic, of twice the wake frequency, is apparently due to drag forces and radiates mostly in the direction of the stream; wire diameter has no effect on sound intensity in the far field, in plane of symmetry.

M. C. Junger, USA

2700. Westervelt, P. J., Acoustic radiation pressure, *J. acoust. Soc. Amer.* **29**, 1, 26–29, Jan. 1957.

Author derives expression for force due to acoustic radiation pressure on an obstacle which both scatters and absorbs sound. The scatterer is an object of arbitrary shape. Analysis, which does not specify a normal boundary impedance and which explicitly takes into account interaction between incident and scattered waves, is in agreement with earlier, more restrictive analysis [Westervelt, AMR **4**, Rev. 4642].

M. C. Junger, USA

2701. Campbell, I. D., The transmission of a plane wave between parallel plates, *Acustica* **5**, 6, 298–302, 1955.

2702. Miyahara, Y., and Richardson, E. G., Ultrasonic relaxation in freon vapors, *J. acoust. Soc. Amer.* **28**, 6, 1016–1019, Nov. 1956.

Experimental data on sound speed and absorption in CCl_2F_2, CCl_3F, $CHClF_2$, and CF_3Cl from Pierce-type interferometer is used to find vibrational relaxation times. All are near 10^{-7} sec. Addition of 10% air gave no detectable effect; helium a small reduction in time; and argon up to 1/3 reduction in time. Authors were apparently unaware of reviewer's work either with pitot tube or shock-wave measurements.

Good agreement is observed among all three methods.

W. C. Griffith, USA

2703. Andreae, J. H., and Lamb, J., Ultrasonic relaxation theory for liquids, *Proc. phys. Soc. Lond. (B)* **69**, 440, 814–822, Aug. 1956.

Authors derive relations among the thermodynamic parameters of liquids as a function of frequency and the ultrasonic absorption and velocity. The expressions are in forms suitable for analysis of experimental results. The theoretical model is that of multiple relaxation processes of the internal degrees of freedom, each with its own relaxation time. In this sense it is a generalization of the work of Davies [*Proc. roy. Soc. Lond. (A)* **226**, p. 24, 1954], which treated only structural relaxation for a single relaxation process. It is valid for the general case of structural relaxation involving changes both in internal energy and in volume, as well as the purely structural (at constant temperature) and purely thermal (at constant volume) relaxation.

The analysis is based on an expansion of the complex adiabatic compressibility in terms of the partial derivatives with respect to

the internal degrees of freedom, where these are governed by simple relaxation or rate equations. Its validity is limited to the case of small absorption per wave length and independence of the internal degrees of freedom. J. L. Stewart, USA

2704. Ledneva, T. M., Temperature-dependent absorption of ultrasonic waves in certain organic liquids according to their saturation curves (in Russian), *Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk* **10**, 10, 71-80, Oct. 1955.

2705. Meyerson, N. L., Noise reduction in pumps and pump systems, *Noise Control* **3**, 2, 27-32, Mar. 1957.

Ballistics, Detonics (Explosions)

(See Revs. 2396, 2652, 2694, 2695)

Soil Mechanics, Seepage

(See also Revs. 2465, 2710, 2711)

2706. Skuratov, V. S., A simplified method of calculating ferro-concrete piling with flexible stringers (in Russian), *Vopr. ekonomiki i tekh. na vodnom transporte* no. 1, 62-88, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1725.

An approximation method is suggested for calculating pile foundations, based on the assumption of hinge joints between the piles and the grillage and the piles and the foundation soil. The calculation of a two-dimensional grillage or cribwork on piles is analyzed on the assumption of elastic deflection of the cross members under any system of vertical and horizontal forces, applied in the axis of the grillage. The cross members are assumed to be continuous, and the piles (hinge) jointed with their lower ends to the soil and with their upper ends to the cross members; the elasticity of the cross beams at the points of attachment of the piles being determined by the compressive distortion of the piles, and yielding of the foundation soil neglected. The gripping of the foot of the pile by the soil, irrespective of the nature thereof, is likewise neglected.

The system is calculated by the method of displacements, the forces in the auxiliary attachments due to the individual linear displacements of the joints of the grillage being first determined. Assuming the vertical, linear displacements of the individual joints of the grillage to be unknown, as well as the horizontal displacement of the cross members, the conditions for equilibrium of the joints are determined.

Courtesy of Referativnyi Zhurnal N. K. Snitko, USSR
Translation, courtesy Ministry of Supply, England

2707. Radulescu, M., Solution of difficult foundation problems of bridges in saline soils (in Rumanian), *Indust. constr. Mater. constr.* **7**, 3, 141-145, Mar. 1956.

Foundation difficulties in saline soils under water-saturated strata are described and their solution presented in connection with construction of a railroad bridge. Special type of concrete caisson was used. J. J. Polivka, USA

2708. Santalova, M. A., Calculation of the general stability of grooved embankments (in Russian), *Bull. All-Union Scientific Institute of Hydrotechnology* **53**, 138-146, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3135.

Accepting the hypothesis of the circular-cylindrical form of the slipping surface, author investigates the arrangement of a grooved non-anchor wall supporting homogeneous soil which possesses the forces of friction and adhesion. The investigation was undertaken with the object of developing a more simple method of calculation of constructions for general stability. In the case of a two-dimensional problem, examining the equilibrium of the volume of soil, limited by the slipping curve, and assuming friction and adhesion completely concentrated along this curve, author obtains an expression for the mean coefficient of internal friction of the soil f_0.

In the case of given characteristics of the soil, the height of the wall H and the depth of the driving in of the groove t, the expression for f_0 is a function of the position of the slipping curve. Its maximum value determines the most dangerous slipping surface.

By graphic analytical means, author finds the coordinates of its center for the most dangerous slipping surface:

$a = 0 \quad b = 0.25\,H$ with coupling $c = 0 \div 0.1$
$a = 0.2\,H \quad b = 0.25\,H$ with coupling $c = 0.2 \div 0.5$

for grooved walls of a height between 2 and 6 m.

Considering the narrow limits of variation of the coordinates of this center, author reduces the expression for the maximum value of the mean coefficient of internal friction f_0 to the form

$$f_0 = \frac{AγH - Bc - Sp}{KγH + Up}$$

in which p is the intensity of the temporary uniformly distributed load on the collapse prism; A, B, K, S and U are parameters, the numerical values of which are given in the work.

The method suggested by the author for checking the construction for general stability consists in comparing the virtual coefficient of internal friction with the maximum value of the mean coefficient f_0 calculated according to the equation adduced above. The total stability of the construction is insured if the inequality $f > f_0$ occurs. The reserve coefficient for the total stability is determined by the equality

$$K = f/f_0.$$

Courtesy Referativnyi Zhurnal A. I. Govyadinov, USSR
Translation, courtesy Ministry of Supply, England

2709. Beskin, M. G., Soil pressure on retaining walls in the presence of a transient surface load (in Russian), *Issled. po teorii sooruzheniy* no. 6, 557-571, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 1665.

The analysis is founded on the assumptions of Coulomb and the theorem of Rebhahn; the latter has been utilized for the determination of the plane of collapse by graphical means. [cf. Prokof'ev, I. P.: "Soil pressure and the calculation of retaining walls," 1947, p. 47.] This graphical construction is used for the case of a broken (discontinuous) cleavage surface of a granular medium, under a transient, combined uniform and concentrated load. The examples analyzed, complex in construction, are of theoretical, but no practical, interest, since the case of a transient load acting on a discontinuous or curvilinear surface would not occur in practice.

An example is analyzed in which the stress curve of the distributed pressure on the wall is plotted: this curve resembles in contour the curve obtained analytically by other authors. Both the graphical and the analytical curves examined are complicated and approximate in their construction.

The paper lacks bibliographical references.

Courtesy of Referativnyi Zhurnal I. P. Prokof'ev, USSR
Translation, courtesy Ministry of Supply, England

Micromeritics

(See also Revs. 2588, 2708)

2710. Chapman, T. G., Groundwater flow to trenches and well-points, *J. Instn. Engrs. Austral.* **28**, 10-11, 275-280, Oct.-Nov. 1956.

Author studies two-dimensional steady groundwater flow with free surface toward trenches by means of an electric analogy. Validity of Darcy's law and isotropy of the medium have been premised with an indication of how to deal with anisotropy. Experiments were carried out by means of paper coated with graphite (Teledeltospaper). Seepage zones in trenches were imitated by means of resistance strips with uniform fall in potential. Free surface lines were approximated by carefully cutting away the paper until potentials along these lines satisfied the appropriate boundary condition. Allowable spacing of wells on lines, in order to replace trenches, has been computed.

Experimental results from the electric model imitating two parallel trenches in a water-bearing stratum show the effect of incomplete penetration of the trenches in respect to the impermeable substratum. Results are given graphically.

H. J. Schoemaker, Holland

2711. Zienkiewicz, O. C., The effect of pore pressures on stresses in gravity dams, *Proc. Amer. Soc. civ. Engrs.* **82,** PO 4 (*J. Power Div.*), Pap. no. 1042, 16 pp., Aug. 1956.

Author presents a general elastic solution for stress distribution in a triangular dam for any arbitrary pressure variation. A particular solution is given for the case where the pore pressure varies discontinuously as a result of a line of drains inside the dam. Results of this analysis are compared with stress distribution obtained using an extension of the Brahtz theory and also by assuming a linear distribution of vertical stress in the material. For the examples given it is shown that the extension of the Brahtz theory is completely misleading, and that the departure of the exact solution from a linear stress distribution is practically insignificant.

G. C. Wallick, USA

2712. Barenblatt, G. I., and Krylov, A. P., Elastic-plastic filtration conditions (in Russian), *Izv. Akad. Nauk SSSR, Technical Sciences Series* no. 2, 5–13, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2999.

The statement of the problem of unsteady filtration of an elastic liquid in a porous medium, characterized, in accordance with the concepts of soil mechanics, by a varying relationship of porosity to stresses during unloading and loading. First of all the existence of the porosity relationship m to the pressure p and of the first invariant θ of the tensor of stresses in the porous medium itself is determined.

Further, from the D'Arcet equations and from the continuity, the differential equation for the pressure is derived

$$\frac{\partial p}{\partial t} = a^2 \Delta p$$

in which

$$a^2 = \frac{k(m_0)}{\mu}\left(\frac{m_0}{K_{zb}} + \frac{\partial m}{\partial p} - \frac{\partial m}{\partial \theta}\right)^{-1}$$

$k(m_0)$ is the penetrability at an initial porosity m_0, μ the viscosity, K_{zb} the elastic modulus of the liquid.

The derivatives $\partial m/\partial p$ and $\partial m/\partial \theta$ within the limits of small variations in porosity, which occurs for real strata, are assumed to be constant.

At the same time during loading and unloading the derivative $\partial m/\partial \theta$ is not identical:

$$\left(\frac{\partial m}{\partial \theta}\right)_{\text{load}} = -\frac{1}{K_1} \qquad \left(\frac{\partial m}{\partial \theta}\right)_{\text{unload}} = -\frac{1}{K_2}, \quad K_2 > K_1$$

Therefore the extension of the zone of increased and reduced pressure will occur differently, to a known extent similar to the unloading wave in a plastic medium which was investigated by Kh. A. Rakhmatulin [*Appl. Math. Mech.* **9**, 1, 1945].

The problem has been examined in this form for the first time in the theory of filtration.

I. A. Charnii, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

2713. Shvidler, M. I., Interference of apertures during elastic conditions of petroleum filtration, *Izv. Akad. Nauk SSSR, Technical Sciences Series* no. 5, 42–49, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 3000.

An approximate solution is given of the problem of interaction of apertures during elastic conditions of petroleum filtration in a homogeneous unlimited stratum for cases of a rectilinear infinite chain of apertures and for a circular battery of apertures. For the case of a rectilinear infinite chain of apertures, a small region is segregated, limited by two infinite straight lines arranged parallel to the axis of the chain, at equal distances L from it, inside which the elasticity of the liquid and stratum is neglected. In the remaining portion of the stratum the motion is calculated according to the laws of elastic conditions. The solution is effected with the aid of methods of operational calculus. A solution is given for the output of one aperture of the chain in the form:

$$Q(t) = \frac{kbP_c \exp(t/a^2)\, Erf(\sqrt{t}/a)}{\mu\left(\frac{1}{2\pi}\log_e \frac{\sigma}{\pi r_c} + \frac{L}{4\sigma}\right)}$$

where k is the penetration, b the power, P_c the difference between the initial stratum pressure and the stagnation pressure which is assumed constant, t time, μ viscosity, r_c the radius of the aperture, σ is half the distance between the apertures,

$$a = \frac{4\sigma}{a}\left(\frac{1}{2\pi}\log_e \frac{\sigma}{\pi r_c} + \frac{L}{4\sigma}\right)$$

a^2 is the coefficient of piezo-conductivity.

The problem for the case of a circular battery of apertures is solved in a similar manner. The results of the calculations for the numerical examples for a rectilinear chain and for a circular battery of apertures are given.

M. D. Rozenberg, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

2714. Lobnaev, E. N., Calculation of the rate of soaring (in Russian), Novoe v. stroitel'noi tekhnike. Sanitarnaya tekhnika, 20–33. Kiev, Izd-vo Akad. arkhitektury Ukr. SSSR, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2882.

A formula is derived for the rate of uniform fall (rate of soaring) of heavy particles in air. The particles are assumed to be spherical, which gives the author the possibility of using the known experimental curve of Wieselsberg for determining the relationship of the resistance coefficient C to the Reynolds number R. For practical calculations, author indicates a formula based on the approximate conception of Wieselberg's curve in a certain range of numbers R with the relationship $C = 4.3(\lg R)^{-2}$. Author suggests a method for calculating the rate of soaring based on the representation of a general formula for the rate of soaring in the form of the relationship of the number R to a certain parameter, including the diameter of the particle and the kinematic viscosity of the air. Introducing the correction coefficient, having regard to the deviation of the form of the particle from the spherical, author constructs nomograms for the graphical determination of the soaring rate and of the solution of the converse solution, for determining the dimension of the particle which at the given speed of the air current is in a suspended state. A number of examples of the calculation are given at the end of the work.

G. I. Barenblatt, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

2715. Olevskii, V. A., The velocity of the free fall of particles in a fluid medium (in Russian), *Zh. prikl. khimii* **28,** 8, 849–856, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2881.

In order to determine the velocity v of the free fall of spherical particles in a liquid and gaseous medium it is suggested that Lyashchenko's diagram should be used [Lyashchenko, P. V., "Gravitation methods of enrichment," Gostoptekhizdat, 1940] in which along the axis of the ordinates the Reynolds numbers R are plotted, and along the axis of the abscissae the nondimensional parameter, equal to the product of the coefficient of resistance multiplied by the square of the Reynolds number, which the author calls the Lyashchenko criterion

$$L = R^2\,\psi = \frac{\pi}{6} g d^3 \nu^{-2} \Delta \qquad \left(L = \frac{\delta - \delta_0}{\delta_0},\ R = \frac{dv}{\nu}\right)$$

in which d is the diameter of the spherical particle, g is the acceleration due to gravity, ν is the kinematic viscosity, δ is the specific gravity of the particle, δ_0 is the specific gravity of the medium.

For the range of values R between 0 and 6000, author suggests the approximate formula

$$L = 3\pi R + \sqrt{3R^{1.5}} + \frac{1}{8} R^2$$

and considers that it more accurately defines the graphical determination R according to the Lyashchenko diagram. For practical calculations it is suggested that the curve $R = f(L)$ should be replaced by a broken line, each of the sections of which is described by the simplified criterion relationship

$$R = KL^n$$

Solving this equation in respect of velocity, we obtain

$$v = K\left(\frac{\pi}{6}\right)^n g^n d^{3n-1} \nu^{1-2n} \Delta^n$$

Author divides the whole region of variation R between 0 and 10^5 into 5 sections (0–1, 1–50, 50–500, 500–2500, 2500–100,000) for each of which he adduces the values K and n; in this, for the first section, the formula obtained coincides with the Stokes formula, for the third, with the Allen formula, for the fourth, with the Lyashchenko-Zegzhda-Karman formula, and for the fifth, with the Rittinger-Newton formula. The formula for the second section has not appeared in the appropriate literature before.

Courtesy Referativnyi Zhurnal I. P. Mazin, USSR
Translation, courtesy Ministry of Supply, England

Geophysics, Meteorology, Oceanography

2716. Grant, F., A problem in the analysis of geophysical data, *Geophysics* **22,** 2, 309–344, Apr. 1957.

The problem is to analyze mapped data into components which may be termed "trend" and "residual." The approach used is polynomial fitting by least squares, following the method of DeLury when the data are evenly distributed (or sampled) and of Kendall when they are not. The DeLury method, however, is extended somewhat in scope to include missing values. A number of statistical tests are discussed which should assist in determining the optimum amount of complexity to ascribe to "trend." The attitude taken throughout this paper is unbiased in the sense that positive and negative residuals are held *a priori* to be equally likely. An example is given of the regional correction of a gravity survey designed to explore for sulphides near Val d'Or, Quebec. In conclusion a brief discussion is given of the advantages of polynomial fitting over smoothing and "gridding" methods from the point of view of labor and costs.

From author's summary

2717. Krylov, Yu. M., Theory and calculation of deep-sea wind waves (in Russian), *Trudi Okeanogr. in-ta* no. 26, 3–86, 1954; *Ref. Zh. Mekh.* 1956, Rev. no. 2852.

The first equation of the theory expresses the balance of the energy of the wind waves in the form

$$\frac{\partial E}{\partial t} = -\frac{\partial}{\partial x}(EU_E) + M_p + M_\tau - E_\mu$$

in which E is the mean wave energy in a pillar of water with a unit base area; U_E is the rate of energy transfer; M_p, M_τ are the energy transmitted to the waves by the normal pressure and tangential stress of the wind per unit of time, respectively; E_μ is the dissipation of energy by turbulent viscosity. The second equation gives the relationship between the steepness $\delta = h/\lambda$ and the increase $\beta = c/U$ of the wind waves (h, λ are the height and length of the wave, c, U are the velocities of the wave and of the wind) and is based on the equilibrium of forces, created by the wind, and of the reactive forces, flow and disturbance in the sea. The latter two forces are expressed in this case by values of the form $\mu\, \partial u/\partial z$, where μ is the coefficient of turbulent viscosity, u is the velocity of the corresponding motion. When comparing both equations, author considers it possible to disregard the three-dimensionality of disturbance, since the breadth of the crest is several times greater than the length of the wave. The conjoint solution of the two basic equations makes it possible to calculate all the mean elements of the waves dependent upon the length of travel, speed of the wind, and the duration of its action. The corresponding results are tabulated by the author.

Assuming that the wave elements are certain random values which are subject to the normal law of distribution, author finds their distribution functions for the given mean characteristics. Examining the distribution functions, author establishes that the highest waves are most frequently the steepest, and the lowest are the flattest. Further, a detailed description is given of the experimental functions of distribution according to wave-recording data and other observation methods. It was shown that wave elements having the greatest height and wave elements having a 5% provision as regards height are of the greatest practical significance, and also elements of "significant" waves according to Sverdrup [Sverdrup G., Munk V., "Wind, disturbance and swell," Izd-vo in lit, 1951].

A table of the elements of large waves dependent upon the parameters indicated earlier is given. Comparison of the data of the calculation with the most reliable observations shows their good agreement. P. S. Lineikin, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2718. Housley, J. G., and Taylor, D. C., Application of the solitary wave theory to shoaling oscillatory waves, *Trans. Amer. geophys. Un.* **38,** 1, 56–61, Feb. 1957.

Authors attempt to determine an effective wave period separating regions of approximation to measured wave celerities, in water of a constant depth, by linear and shallow-water theories. Calculations of solitary wave celerity are based upon the sum of still-water depth and wave height rather than on the correct value of total crest elevation above the bottom. Effective period for constant wave height is defined as the period of intersection of graphs of $c/c_0 - 1$ and $1 - c/c_s$ versus wave period, where c is measured celerity and c_0, c_s are computed from linear and shallow-water approximations, respectively. Waves are generated by a trial and error method using a hydraulic system actuated by cams having ratios of forward stroke to total wave period of 1/16 to 8/16 and wave height to water depth ratios of 0.05 to 0.50.

R. A. Fuchs, USA

2719. Marks, W., On the status of complex wave generation in model tanks, *David W. Taylor Mod. Basin Rep.* 1069, 22 pp., July 1956.

A survey is made of all those tank facilities that are known to experiment with the generation of model complex seas or that are planning to experiment in this field.

The wave-generating systems are divided into two classes: (a) those intended to produce long-crested irregular waves, and (b) those intended to produce short-crested irregular waves. The tank installations are briefly described. Emphasis is given to the different techniques used to generate irregular waves in the laboratory. These methods range from the manual application of a paddle to stir up the water, to the precise reproduction of the sea surface, at any point in the tank.

It is found that most towing tanks which deal in irregular waves are restricted to the long-crested variety owing to the existing long channel test facilities. Some basins are building new facilities for work in oblique-regular and short-crested seas; others are revamping present installations.

From author's summary

2720. Mason, H. P., and Gardner, W. N., A limited correlation of atmospheric sounding data and turbulence experienced by rocket-powered models, *NACA TN* 3953, 51 pp., Apr. 1957.

Atmospheric turbulence as experienced by rocket-powered models and temperature lapse-rate data obtained from rawinsonde soundings have been analyzed and compared in 38 cases by using an assumed temperature lapse-rate stability boundary as a basis for comparison. All the data used in the analysis were obtained from tests made at the Langley Pilotless Aircraft Research Station at Wallops Island, Va.

A limited correlation has been obtained which indicates that atmospheric conditions classified as being unstable will generally be turbulent; however, a marginal or a stable classification does not necessarily indicate smooth air. Thus a large percentage of turbulence can be avoided by making flight tests only during marginal or stable lapse-rate conditions.

From authors' summary

2721. Uspenskii, B. D., Theory of local changes of pressure near the ground (in Russian), *Meteorology and Hydrology* no. 1, 3–7, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2971.

A continuation of the author's work [see *Ref. Zh. Mekh.* 1956, Rev. 1951] devoted to obtaining a formula for a local change in the absolute altitude H of the isobaric surface near the mean level of the troposphere (700-500 mb).

Starting from a simplified equation of vortex transfer and geostrophic approximation, author obtains

$$\frac{\partial H}{\partial t} = \frac{1}{ml}(H, \Delta H) + \frac{l^2}{m}\left(\frac{\partial \bar{u}}{\partial x} + \frac{\partial \bar{v}}{\partial y}\right) \qquad [1]$$

in which t is the time, $l = 2\omega \sin \varphi$ is Coriolis' parameter; $\bar{u}$, $\bar{v}$ are the velocity components of the wind averaged according to height on the horizontal axes x and y.

$$\Delta = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$$

$$(H, \Delta H) = \frac{\partial H}{\partial x}\frac{\partial \Delta H}{\partial y} - \frac{\partial H}{\partial y}\frac{\partial \Delta H}{\partial x}$$

m is the coefficient of proportionality in the empirical equation

$$\Delta \frac{\partial H}{\partial t} = -m \frac{\partial H}{\partial t}$$

The basic object of the article in question is to obtain an equation for the local change of pressure p_0 near the ground. Author uses the equation of heat flow, the barometric formula (differentiating it according to time), and the continuity equation. The solution of these equations together with [1] enables the vertical velocity and the local derivatives from the temperature and pressure near the ground according to time to be found. The equation for the local variation in pressure near the ground assumes the form

$$\frac{\partial p_0}{\partial t} = \frac{b}{lm}(H, \Delta H) + \frac{l^2 b}{m}\left(\frac{\partial \bar{u}}{\partial x} + \frac{\partial \bar{v}}{\partial y}\right) + r\left(\bar{u}\frac{\partial \overline{T}}{\partial x} + \bar{v}\frac{\partial \overline{T}}{\partial y}\right) - \frac{r(\gamma_a - \bar{\gamma})(p_0 - p^*)}{2g\rho}\left(\frac{\partial \bar{u}}{\partial x} + \frac{\partial \bar{v}}{\partial y}\right) - r\left(\frac{\partial \overline{T}}{\partial t}\right)_H \qquad [2]$$

where

$$b = \frac{p_0}{R\overline{T}}, \qquad r = \frac{p_0}{\overline{T}} \ln \frac{p_0}{p^*}, \qquad \gamma = -\frac{\partial \overline{T}}{\partial z}$$

γ_a is the dry adiabatic gradient, R the specific gas constant, g is the acceleration due to gravity, ρ is the atmospheric density, $(\partial \overline{T}/\partial t)_H$ is the speed of the nonadiabatic temperature change, p^* is the pressure on the mean level H; the lines over the values refer to the average according to the pressure within the limits of the layer between p_0 and p^* (an exception is formed by the second component in which the constituent velocities are averaged from p_0 to a pressure of an order of 100–200 mb or to the upper limit of the atmosphere). A qualitative interpretation is given of separate terms [2].

The problem of the practical use of Eq. [2] is left open in the article. L. G. Matveev, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

2722. Dryden, W. A., On the flux of eddy energy in small-scale turbulent motion, *J. Meteor.* **13,** 5, 433–447, Oct. 1956.

Author is concerned with experimental verification of part of the theory of eddy energy transformation developed by Blackadar, which partly depends on the hypothesis that the mean flux of eddy energy relative to the mean motion is in the direction of decreasing eddy energy. Data from experiments by Townsend (plane boundary layer and wake of a circular cylinder) and Laufer (flow in a round pipe) are analyzed and good agreement found, except very near the boundaries. The author's own free-turbulence experiment with a low-speed horizontal jet of air is then described, but the agreement obtained in this interesting but difficult experiment, though generally supporting Blackadar's hypothesis, is not quite as satisfactory. R. P. Pearce, Scotland

2723. Ertel, H., A problem in meteorological acoustics (in German), *S. B. dtsch. Akad. Wiss.* no. 2, 18 pp., 1955.

Ertel pursues von Humbolt's suggestion that low-level turbulent eddies of thermal origin are important in diurnal variation of propagation of sound intensity in the lower layer of the earth's atmosphere. He shows that thermoconvective temperature variations in the atmosphere cause a daily periodic attenuation of sound intensity over and beyond the effects of the mean vertical temperature distribution, giving a daytime minimum of sound intensity propagation.

Paper is largely mathematical. R. C. Staley, USA

2724. Pearcey, T., and Hill, G. W., A theoretical estimate of the collection efficiencies of small droplets, *Quart. J. roy. meteor. Soc.* **83,** 355, 77–92, Jan. 1957.

The effective collision cross sections between pairs of small water droplets, falling freely through air under the influence of gravity, have been computed on the assumption of hydrodynamical effects alone being important. It has been assumed that each droplet tends to fall freely at its terminal velocity with respect to the surrounding medium, which also moves under the influence of the motion of a neighboring droplet. By the use of previously computed fields of flow of a viscous medium around a uniformly translated sphere, the trajectories of motion of one droplet with respect to another were computed for a range of droplets having radii between 4 μ and 200 μ.

It is found that the collision cross sections increase to values considerably greater than the corresponding geometrical cross section as the droplets approach equality of size. As the difference in size increases, the collision cross section decreases to values close to the geometrical cross section, and finally decreases to zero. For any one particular size of the collecting droplet there is a minimum size of collected droplet below which no collection is possible. This size decreases with increasing size of the larger droplet greater than 10 μ in radius. For droplets smaller than 10 μ in radius, collision can occur only between droplets of nearly equal size. The results could account for coalescence becoming an important factor in the rapid formation of raindrops for droplets of radii greater than 10 μ. From authors' summary

2725. Kuo, H.-L., On quasi-nondivergent prognostic equations and their integration, *Tellus* **8,** 3, 373–383, Aug. 1956.

Author obtains a general two-dimensional wind-pressure relationship very similar to that obtained by other workers in this field. This wind-pressure relationship is used in determining the initial conditions and governing equations of a three-dimensional atmospheric model which eliminates errors due to the quasi-geostrophic approximation. Author shows how the resulting partial differential equation can be solved by Green's method. Influence functions are evaluated for certain standard atmospheres.

While reviewer thinks this paper makes an important contribution to dynamical meteorology, he does not consider that it is likely to be of any great interest in the field of engineering, although it does serve as an example of the way Green's method may be used to solve the elliptic type of partial differential equations.

F. H. Bushby, England

Lubrication; Bearings; Wear

(See also Rev. 2534)

2726. Slibar, A., and Paslay, P. R., On the theory of grease-lubricated thrust bearings, ASME-ASLE Third Lubrication Conf., Atlantic City, N. J., Oct. 1956. Pap. 56-LUB-1, 6 pp.

In this analysis, the lubricant is assumed to have a definite yield condition, dependent upon the value of the second invariant of the reduced stress tensor, which may be interpreted in terms of the octahedral shear stress. The form of the invariant is chosen so that its value is the shear stress in a state of two-dimensional pure shear. After yielding, the lubricant is assumed to behave as a viscous material with constant viscosity.

The solution is obtained for a plane thrust bearing considering the case in which the lubricant flow is mainly in the circumferential direction, with a correction being obtained by a perturbation procedure to allow for the radial flow due to the feeding in of lubricant at the inner radius of the bearing. The results of the analysis are displayed by curves relating dimensionless variables, and these would be of value to the bearing designer.

W. O. Richmond, Canada

2727. Crook, A. W., Simulated gear-tooth contacts: some experiments upon their lubrication and subsurface deformations, Instn. mech. Engrs., Prepr., 12 pp., Nov. 1956.

Hydrodynamic lubrication was found to exist between sliding surfaces of disk machines as demonstrated by electrical resistance measurements. Metal-to-metal contact existed during the run-in period but was shown to decrease rapidly with time. The resistance measurements after run-in were shown to depend upon the temperature of the disks as influenced by load. Variations of electrical resistivity of the oil film with temperature were considered. Profilograms of disk surface before and after run-in are shown.

Subsurface deformation was investigated with rolling and sliding surfaces by distortion of straight lines scribed radially on the disks and by silver-soldered-nickel wire inserted in radial holes. Distortion of the surface due to plastic deformation was found to be not as expected but such that the surface material was drawn toward the disk line of contact for rolling and in the direction of forces tangent to the surface when sliding. Micrographs are presented to further substantiate the foregoing phenomena.

C. J. Vogt, USA

2728. Diyachkov, A. K., Investigation of heat generation in the case of friction of plain bearings (in Russian), Friction and wear in machines, Symp. 10, Moscow, Izd-vo Akad. Nauk SSSR, 297–335, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2919.

The bearings of the big end of a connecting rod of a V-type engine were tested on a testing machine. The bearings were subjected to complex and simple loading with the aid of four rotating loads. At the same time the temperature of the oil entering and leaving the bearing was measured by thermocouples. The heat generation in the bearing was determined, which theoretically and experimentally was divided into two forms: heat generation in the loaded portion of the bush and heat generation in the nonloaded portion of the bush.

As a result of the experiments, semi-empirical formulas were obtained for calculating the heat generation in the loaded and nonloaded portions of the bush, taking into account the position of the oil hole, the form of loading, the rigidity of the connecting rod head, the influence of the quality of the oil. The photograph of an oil flow in the clearance of a connecting rod taken on a transparent insert of organic glass is also given.

Courtesy Referativnyi Zhurnal • A. I. Golubev, USSR
Translation, courtesy Ministry of Supply, England

Marine Engineering Problems

(See also Revs. 2433, 2437, 2582)

2729. Eggers, K., Resistance of twin-hull ships (in German), *Jahrbuch Schiffbautech. Gesellsch.* **49,** 516–539, 1955.

The resistance of twin-hulled ships is investigated both experimentally and theoretically. Two pairs of ship models were towed at various lateral and longitudinal spacings and at various speeds in both deep and shallow water, and the results are compared with calculations based upon the Michell-Stretensky theory of the wave-making resistance of a ship. Considering the approximate nature of the theory, the agreement with experiment is very good. Work is of additional interest because it indicates how the resistance of a ship is influenced when it is travelling near another on a parallel course.

H. Rouse, USA

2730. Harder, K. C., and Rennemann, C., Jr., On boattail bodies of revolution having minimum wave drag, *NACA Rep. 1271,* 9 pp., 1956.

See AMR **9,** Rev. 485.

2731. Granville, P. S., Skin friction formulations, *David W. Taylor Mod. Basin Rep.* 1063, 5 pp., July 1956.

2732. Ridland, D. M., Investigation of high length/beam ratio seaplane hulls with high beam loadings. Hydrodynamic stability. Part 13—The effect of afterbody angle on stability and spray characteristics, *Aero. Res. Counc. Lond. curr. Pap.* 236, 20 pp. + 11 figs., 1956.

The effects of afterbody angle on longitudinal stability, spray, and directional stability characteristics and elevator effectiveness are deduced from the results of tests on three models of the series which were alike in every major respect except that of afterbody angle. The models had afterbody angles of 4°, 6°, and 8°, respectively.

It was found that increasing afterbody angle improved longitudinal stability characteristics considerably, both with and without disturbance, increased trim generally, gave a slight improvement in spray and directional stability characteristics and increased elevator effectiveness. The best hydrodynamic configuration was that with the 8° afterbody angle.

From author's summary

2733. Taggart, R., A ship for research in naval architecture, *J. Amer. Soc. nav. Engrs.* **69,** 1, 51–57, Feb. 1957.

2734. Schertel, H. F. V., Hydrofoil boat development, theory and application (in German), *ZVDI* **98,** 36, 1955–1965, Dec. 1956.

2735. Havelock, T. H., The damping of heave and pitch: a comparison of two-dimensional and three-dimensional calculations, *Trans. Instn. nav. Arch. Lond.* **98,** 4, 464–468, Oct. 1956.

A spheroid wholly immersed in water is considered. Rate of energy loss when spheroid oscillates is calculated from three-dimensional flow and from the strip method. Ratio of the two results is plotted versus $\sigma^2 L/g$, where σ is circular frequency of oscillation and L is spheroid length.

Ratio for heaving rises rapidly at first and may be taken as unity when $\sigma^2 L/g$ is greater than about 6. Ratio for pitching rises slowly at first and then rapidly and may be taken as unity when $\sigma^2 L/g$ exceeds about 8.

Author notes that only general indications can be expected in applying results to surface ships, as flow round a completely submerged solid may differ considerably from that round a floating body. Present work seems to agree with experimental results for ship models.

In discussion of paper, G. Vosser, NSMB, presents analogous curves for a Michell ship. These curves are comparable with those given by present author. E. Steneroth, Sweden

2736. McGoldrick, R. T., and Russo, V. L., Hull vibration investigation on SS Gopher Mariner, *David W. Taylor Mod. Basin Rep.* 1060, 437–495, July 1956.

2737. Irkhin, A. P., and Stephanuk, E. I., Attitude when in motion and velocity characteristic of freight motor vessels of the "Great Volga" type (in Russian), *Rech. Transport* no. 3, 15–19, 1955; *Ref. Zh. Mekh.* 1956, Rev. no. 2861.

Results are described of the systematized model and natural tests of a freight motor vessel of the type "Great Volga" for the determination of its resistance to movement and of the value of its attitude when in motion in shallow water and in a canal. The model tests were made in the small TSNIIRF reservoir, and the natural tests in different reaches of the Volga and in the "Moscow" canal. The object of the tests was to determine the depth which can be safely navigated and the reserves of water under the bottom during the movement of vessels of this type under full power of the main engines.

On the basis of the analysis of the tests, authors conclude that the determination of the attitude of the vessel in the conditions described above, starting merely from the value of the reduction of the level of the free surface of water at the sides of the moving vessel, as was suggested by the Hydraulics section of the Academy of Sciences, Ukr. SSR in 1952, is not confirmed by the test and distorts the essence of the phenomenon.

In their opinion, it is also necessary to consider the dynamic variation of the difference which is the result of the change in the general picture of pressure distribution over the surface of the hull of the vessel which is moving in a confined flow.

In conclusion, the values recommended for vessels of the "Great Volga" type for safely navigable depths and reserves of water in cm underneath the bottom are given for those motor vessels in the case of their varying attitude. Abstractor's note: The suggested values of safely navigable depths and reserves of water under the bottom are clearly excessive and are subject to further correction, mainly from obtaining and extending operational data.

Courtesy Referativnyi Zhurnal I. V. Girs, USSR
Translation, courtesy Ministry of Supply, England

2738. Jasper, N. H., and Wigle, B. M., Motions of the SS Silver Mariner in a State 5 sea, *David W. Taylor Mod. Basin Rep.* 1067, 27 pp., Oct. 1956.

The motions of the SS Silver Mariner in a State 5 sea were measured during a voyage from New York to Bremerhaven, Germany. The objective of these tests was to determine the roll, pitch, and heave motions that this type of vessel would be likely to experience in a State 5 sea for various conditions of speed and relative heading. The mean square values of the variation in ship motion are given as a function of shaft rpm for a constant heading and as a function of heading for constant shaft rpm. The largest values of motion measured during the tests are given as well as the probabilities of exceeding a given magnitude of ship motion for various combinations of speed and heading.

From authors' summary

2739. Caldwell, J. B., The strength of ships' superstructures under transverse loads due to wind and waves, *European Shipbuilding* **6,** 1, 23–30, 1957.

2740. Levchenko, S. L., On the method of measuring the oscillation of river vessels in a swell (in Russian), *Trudi Mov. gidrofiz. in-ta Akad. Nauk SSSR* **5,** 39–46, 1955; *Ref. Zh. Mekh. 1956,* Rev. no. 2858.

An experiment is described of the measurement and recording of oscillation amplitudes and velocities of river vessels with simultaneous measurement of the swell, made in 1951–1952. The measurements were made at various intensities of swell on six tugs, three freight and passenger ships, and on one launch. The oscillation amplitude and velocity were determined by a photorecorder for oscillation, and also by an optical goniometer and wave meter. The type of photorecorder developed enabled simultaneous recording on the oscillograph tape of the elements of lateral, keel and vertical oscillation (roll, pitch, and toss) to be made of a vessel with parallel indication of the time (of the order of 300–500 amplitudes).

Courtesy Referativnyi Zhurnal I. V. Girs, USSR
Translation, courtesy Ministry of Supply, England

2741. Belgova, M. A., and Maksimadzhi, A. I., Practical methods of calculating coverings in vessels and calculation of brackets in the case of calculation of ribbed frames (in Russian), *Trans. Central Scientific Institute for the River Fleet* **27,** 29–67, 1954; Ref. Zh. Mekh. 1956, Rev. no. 3167.

In the calculations of the strength of hull coverings it is necessary to overcome difficulties connected with determination of the coefficients of fixing in of main direction beams and of cross braces, which make up the assembly of these coverings.

An analysis is made of the influence of the value of these coefficients of sealing as applied to various systems of assembly of the coverings met with on vessels for internal waterways, and practical, i.e. approximate, methods of calculating these coverings with the use of tables and graphs given in the work are established.

Further, the problem is examined of the calculation of the influence of brackets in the opening of the static indeterminacy of assembly beams of a ship's hull.

On the basis of the investigation, a method for the approximate calculation of the influence of these brackets is recommended.

Courtesy Referativnyi Zhurnal Yu. A. Shimanskii, USSR
Translation, courtesy Ministry of Supply, England

2742. Tachmindji, A. J., The potential problem of the optimum propeller with finite hub, *David W. Taylor Mod. Basin Rep.* 1051, 17 pp., Aug. 1956.

The potential problem is solved for the circulation distribution of an optimum propeller with a finite number of blades and a hub of constant diameter. The effect of the hub has been calculated for specific cases, showing that it becomes important for propellers with large hub diameters and small number of blades and increases with increasing pitch. From author's summary

2743. Tietjens, O., Contribution to propeller theory (in German), Jahrbuch der Wissenshaftlichen Gesellschaft für Luftfahrt, 236–245; Braunschweig, Friedr. Vieweg & Sohn, 1955.

The induced efficiency is calculated as a function of speed ratio coefficient of thrust and number of blades. The total efficiency is obtained by taking into account the profile drag including the losses due to cavitation. Results obtained for marine propeller are represented in diagrams which enable obtaining the maximum possible efficiency, the most favorable diameter, and other design data when the forward speed of the propeller, its thrust and number of revolution are given. No practical verification is given. M. Kataoka, Japan

2744. Mason, F. T., A review of naval propulsion engineering progress in the last ten years, *N. E. Cst. Instn. Engrs. Ship. Trans.* **73,** 1, 37–50, Nov. 1956.

2745. Concerning AMR 9, Rev. 3275 (October 1956) Bazer, J., and Karp, S. N., On a steady-state potential flow through a conical pipe with a circular aperture, *J. rational Mech. Analysis* **5,** 2, 277–322, 1956.

The review states in paragraph 1 that "the solution of the Laplace equation with adequate boundary conditions is obtained in the form of *infinite products of integrals of Legendre functions.*" (the italics are ours.) Now the only correct part of this statement is that we do employ Legendre functions in our integral representations. These representations are of the following form [cf. p. 288 of our paper]:

$$u^1(r,\theta) = \frac{1}{2\pi i}\int_C r^{-(\nu+\frac{1}{2})} P_{\nu-\frac{1}{2}}(\cos\theta) A(\nu)\,d\nu,\quad 0 \le \theta \le \theta_0$$

$$u^2(r,\theta) = \frac{1}{2\pi i}\int_C r^{-(\nu+\frac{1}{2})} P_{\nu-\frac{1}{2}}(\cos\theta) B(\nu)\,d\nu,\quad \theta_0 \le \theta \le \pi.$$

Here, C is an appropriate contour in the complex ν-plane, θ_0 is the angle between a generator and the axis of the cone, and $A(\nu)$ and $B(\nu)$ are suitable meromorphic functions which involve the zeros of the Legendre functions $P_{\nu-\frac{1}{2}}(\pm\cos\theta_0)$. Clearly, infinite products of Legendre functions do not appear.

The reviewer asserts: "The reviewer can conceive that the discussions could be of interest if new mathematical methods or transformations have been used; this could not be verified." It is a fact, however, that the standard techniques, such as the use of Mellin transformation coupled with separation-of-variables, do not suffice to solve the problem and must be supplemented by function theoretic methods. As we have plainly stated on page 1 of our paper, a variant of the Wiener-Hopf technique is employed. This method, as is well known, has hitherto been employed successfully in solving many diffraction problems in which the standard transform and separation-of-variables methods do not apply. Unless the application of Wiener-Hopf methods to flow problems in coordinate systems such as we have employed here is regarded as "standard," the reviewer's criticism is unwarranted.

The reviewer states: "The uniqueness proof is necessary since the uniqueness proof of the Laplace equation is given in text books (for instance "Methoden der Math. Physik," Courant, R., and Hilbert, D., 2nd edition, 1937, Vol. 1, p. 274 ff)." If the reviewer is referring to the uniqueness proof in *Vol. 11* on p. 274 ff., where the pertinent material is to be found, then it should be pointed out that the proof applies only to finite domains and to the Dirichlet problem. The basic tool of the proof is the maximum principle for harmonic functions.

It is essential to note that we are concerned with the *Neumann* problem for a boundary possessing sharp edges. The maximum principle in itself is insufficient to yield a uniqueness proof for such a case. Thus, far from being *directly* applicable, Courant-Hilbert does not even apply in *spirit* to our case. In fact it is well known that unless the derivatives are suitably restricted in magnitude, the solutions of potential problems involving edges are not uniquely determined. For example, one could add any multiple of the function $r\,\partial u/\partial r$ to our solution u, were not the edge behaviour restricted.

The reviewer states: "The solutions are of little interest in fluid flow since fluid flow does not behave *that way* in the region of interest, namely near the aperture of the cone." (Italics are ours.) We are not quite certain what is meant by "that way." If the reviewer means that the velocity of the fluid is $0(\delta^{-\frac{1}{2}})$ near the circular edge of the cone, where δ is the distance from the edge, then his criticism is unwarranted for at least two reasons. First, we have nowhere claimed that a real fluid behaves "that way." Second, we should like to point out that the literature on fluid dynamics and acoustics abounds in useful examples (Cf. especially Lamb; Hydrodynamics, Dover Edition, pp. 74, 75 where a two-dimensional version of our problem is discussed.) where this minimal type of singularity appears. The singularity is a necessary mathematical consequence of the idealization of potential flow about a perfectly sharp edge. (Ibid. pp. 105 ff. The singularity reflects the fact that flow around a sharp bend requires high speeds.) It seems absurd to emphasize this well-known point in connection with our paper.

Finally, the reviewer states: "However, the solutions might apply to other physical phenomena such as flow of electricity." This indeed is a possible application (but the minimal singularity is nonphysical here too, for real materials). But, as we stated plainly on page 2 of our paper, "It should be mentioned that the solution we give here is useful in deriving approximated expressions for the far field in the corresponding boundary-value problem involving the diffraction of sound waves. Assuming suitable excitation inside the cone at infinity, these expressions for the far field are obtained by assuming the wave length of the sound waves to be large compared to the aperture dimensions and then using certain properties of the solution of the potential problem. In this connection two well-known procedures may be employed. Both are based on the fact that in the large wave length limit the solution of the time-reduced wave equation is approximated, at least in the neighborhood of the aperture, by the static solution, and on the fact that the far field may be obtained from the aperture field. The static solution is the solution of the above-mentioned potential problem. The first method is the so-called static method of Rayleigh ... and the second is the more powerful variational procedure of Schwinger and Levine .... In the first method it is necessary to know only a gross characteristic of the static aperture field, namely the conductivity of the opening. The second method, on the other hand, requires a detailed knowledge of the low-frequency aperture field, for which the static field in the aperture is useful as a first approximation. Since explicit expressions for the conductivity of the opening and for the aperture field are obtained from our solution of the steady-flow potential problem, both procedures may be successfully employed. For the sake of brevity we shall not discuss this application here. It may be mentioned, however, that the results of the application of the Rayleigh method have been given in a recent report ... by the present authors." (Rayleigh applied the method to the case of a circular or elliptic hole in an infinitely thin rigid wall, since the solution for other geometries was not known to him.)

2746. Concerning AMR 10, Rev. 455 (February 1957): Hill, R., The mechanics of machining: a new approach.

Reviewer has entirely misunderstood aims and results of paper. The first sentence of the Summary clearly puts the suggestion that *different* initial conditions may lead to different steady states; reviewer misquotes me as saying that *given* initial conditions may lead to different steady states. His review consists merely in demolishing this Aunt Sally of his own devising, and makes no reference to the essential point of the paper. This was to show that certain shear-plane inclinations (for instance that suggested by Emst and Merchant) imply overstressing of certain regions and therefore have to be rejected as impossible. The correct value, or values if my initial suggestion turned out to be right, lies in the remaining range—which is comparatively narrow.

R. Hill, England

2747. Concerning AMR 10, Rev. 903 (March 1957): Book. Fifth symposium (international) on Combustion. Combustion in engines and combustion kinetics, Univ. of Pittsburgh, Pittsburgh, Pa., Aug. 30-Sept. 3, 1954. New York, Reinhold Publishing Corp., 1955, xxvi + 802 pp. $15.

Reference is made to the word aerothermodynamics as coined by von Karman—the word should have been aerothermochemistry.

A. K. Oppenheim, USA

2748. Concerning AMR 10, Rev. 935 (March 1957): The correct bibliographical heading should be: Goodman, L. E., Rosenblueth, E., and Newmark, N. M., Aseismic design of firmly founded elastic structures, *Trans. Amer. Soc. civ. Engrs.* **120,** 782–802, 1955.

Books Received for Review

August 1957 Issue

BECKENBACH, E. F., Modem mathematics for the engineer, New York, McGraw-Hill Book Co., Inc., x + 514 pp. $7.50.

BEGEMAN, M. L., Manufacturing processes, New York, John Wiley & Sons, Inc., 1957, 4th edition, xii + 612 pp. $8.00.

BEYER, R. T., and WILLIAMS, A. O. Jr., College physics, New York, Prentice-Hall, 1957, xi + 660 pp. $7.50.

BOSS, P., Grundlagen der technischen Hydromechanik, München, Verlag von R. Oldenbourg, 1956, 60 pp., DM 9.

BRANK, L., Vector analysis, John Wiley & Sons, Inc., New York, 1957, xiii + 282 pp.

CHURCHMAN, C. W., ACKOFF, R. L., ARNOFF, E. L., Introduction to operations research, New York, John Wiley & Sons, Inc., 1957, x + 645 pp. $12.00.

CONDOYANNIS, G. E., Scientific German, New York, John Wiley & Sons, Inc., 1957, x + 164 pp. $2.50.

CORCORAN, W. H., OPFELL, J. B., and SAGE, B. H., Momentum transfer in fluids, New York, Academic Press Inc., 1956, xi + 394 pp. $9.00.

DUGAS, R., A history of mechanics, New York, Central Book Company, Inc., 1955, 671 pp. $15.00.

FLUGGE, S., Edited by, Handbuch der Physik (encyclopedia of physics) Geophysik, II (Geophysics II), Vol. XLVIII, Berlin, Springer-Verlag, 1957, viii + 1045 pp., DM 198.

GAUDIN, A. M., Flotation, New York, McGraw-Hill Book Company, Inc., 1957, second edition, x + 573 pp. $12.50.

HEYMAN, J., Plastic design of portal frames, New York, Cambridge University Press, 1957, viii + 104, $2.00.

JENSEN, A., Applied strength of materials, New York, McGraw-Hill Book Company, Inc., 1957, xiii + 343 pp. $5.75.

JOHNSTONE, R. E., and THRING, M. W., Pilot plants, models, and scale-up methods in chemical engineering, New York, McGraw-Hill Book Company, Inc., 1957, xi + 307 pp. $9.50.

KRYNINE, D. P., Principles of engineering geology and geotechnics, New York, MeGraw-Hill Book Company, Inc., 1957, xiii + 725 pp. $10.00.

LOCKE, W. N., Scientific French, New York, John Wiley & Sons, Inc., 1957, x + 112 pp. $2.25.

MCDOWELL, C. H., A short dictionary of mathematics, New York Philosophical Library, 1957, xiii + 63 pp. $2.75.

Metrology of gage blocks, Cir. 581, Washington, D. C., Department of Commerce, National Bureau of Standards, 1957, x + 119 pp. $1.50.

MICKLEY, H. S., SHERWOOD, T. K., and REED, C. E., Applied mathematics in chemical engineering, New York, McGraw-Hill Book Company, Inc., 1957, second edition, xii + 413 pp. $9.00.

MORRILL, B., Mechanical vibrations, New York, The Ronald Press Company, viii + 262 pp. $6.50.

NAGLER, J., Blätter fur Technikgeschichte, Vienna, Springer-Verlag, 1953, 112 pp. $1.55.

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Third U. S. National Congress of Applied Mechanics Announced

Brown University, Providence, R. I., June 11–14, 1958, to be headquarters

The U. S. National Congress of Applied Mechanics is held every fourth year under the auspices of the U. S. National Committee on Theoretical and Applied Mechanics, a joint committee of the American Institute of Chemical Engineers, the American Mathematical Society, the American Physical Society, the American Society of Civil Engineers, The American Society of Mechanical Engineers, the Institute of the Aeronautical Sciences, and the Society of Experimental Stress Analysis. These congresses are planned to supplement the International Congress of Applied Mechanics but not to compete with it. Accordingly, no effort is made to attract papers from outside the United States and Canada, although there is no rule against their presentation.

All research workers in the field are cordially invited to submit papers constituting original experimental or theoretical contributions to Applied Mechanics, including mechanics of rigid bodies and deformable solids, mechanics of fluids and gases, thermodynamics and heat transfer. It is expected that papers accepted by the Editorial Committee with the advice of recognized authorities and presented at the congress, will be published in full in the proceedings of the congress.

To be considered for presentation at the congress, complete papers and manuscripts must be submitted to the chairman of the Editorial Committee before Jan. 1, 1958; to be scheduled for presentation the final manuscript of a paper must have been accepted before May 1, 1958. To avoid delays caused by overburdening reviewers and editorial staff, authors are urged to submit manuscripts well ahead of the deadline of Jan. 1, 1958.

The papers will be grouped by subject and 30 minutes will be allotted for presentation and discussion of each paper. Arrangements will also be made for general lectures by outstanding authorities on subjects of general interest to members of the congress. Facilities will be provided for informal discussions and social meetings.

The personnel of the Organizing Committee includes the following: William Prager, Mem. ASME, chairman; D. C. Drucker, Mem. ASME, secretary; E. H. Lee, Mem. ASME, treasurer; R. M. Haythornthwaite, chairman, Editorial Committee; and E. T. Onat and E. T. Shield, Committee on Arrangements.

The Editorial Committee, in addition to Mr. Haythornthwaite, the chairman, lists the following: L. H. Donnell, Mem. ASME; M. M. Frocht, Mem. ASME; J. N. Goodier, Mem. ASME; Arthur Kantrowitz; Hans W. Liepmann; P. M. Naghdi, Assoc-Mem. ASME; Walter Ramberg, Mem. ASME; Hunter Rouse, Mem. ASME; W. R. Sears; J. J. Stoker; and E. Wenk.

Inquiries regarding the congress should be addressed to the secretary of the congress at Brown University, Box D, Providence 2, R. I.

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